TES V

MANAGEMENT OF WHOLE-STRUCTURE DEMOLITION DEBRIS CONTAINING LEAD-BASED PAINT

Prepared for

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LIST OF ACRONYMS

AAS	-	Atomic Absorption Spectrometry
AEHA	-	U.S. Army Environmental Hygiene Agency
ARARs	-	Applicable and Relevant or Appropriate Requirements
APCD	-	Air Pollution Control Device
ATSDR	-	Agency for Toxic Substances Disease Registry
BDAT	-	Best Demonstrated Available Technology
BRAC	-	Base Realignment and Closure
CAA	-	Clean Air Act
C/D	-	Construction and Demolition
CDC	-	Centers for Disease Control
CFR	-	Code of Federal Regulations
CKD	-	Cement kiln dust
CPSC	-	Consumer Product Safety Commission
CT DEP	-	State of Connecticut Department of Environmental Protection
DHA	-	Denver Housing Authority
DOD	-	U.S. Department of Defense
DOE	-	U.S: Department of Energy
DQOs	-	Data quality objectives
EP	-	Extraction procedure
EPA	-	U.S. Environmental Protection Agency
ESD	-	U.S. Environmental Protection Agency, Environmental Services Division
EMSL-ORD	-	U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory - Office of Research and Development
FR	-	*Federal Register*
HUD	-	U.S. Department of Housing and Urban Development
HSWA	-	Hazardous and Solid Waste Amendments
kg	-	Kilograms
LBP	-	Lead-based paint
LBPPPA	-	Lead-Based Paint Poisoning Prevention Act
LDRs	-	Land Disposal Restrictions
LHA	-	Louisville Housing Authority
MCL	-	Maximum contaminant level
mg/cm^2	-	Milligrams/square centimeter
mg/kg	-	Milligrams/kilogram
mg/L	-	Milligrams/liter
mL/g	-	Milliliters/gram
MS/MSD	-	Matrix Spike/Matrix Spike Duplicate
MSW	-	Municipal solid waste
NEWMOA	-	Northeast Waste Management Officials' Association
OPPT	-	U.S. Environmental Protection Agency - Office of Pollution Prevention and Toxics
ORP	-	Oxidation reduction potential
OSHA	-	Occupational Safety and Health Administration
OSWER	-	U.S. Environmental Protection Agency - Office of Solid Waste and Emergency Response
pcd	-	Pounds per capita per day
ppm	-	Parts per million

LIST OF ACRONYMS
(Continued)

QA/QC	-	Quality Assurance/Quality Control
RMA	-	Rocky Mountain Arsenal
RCRA	-	Resource Conservation and Recovery Act
SPLP	-	Synthetic Precipitation Leaching Procedure
SWAIP	-	Special Waste Authorization and Implementation Plan (South Carolina)
TCLP	-	Toxicity Characteristic Leaching Procedure
µg/dl	-	Micrograms per deciliter
µg/kg	-	Micrograms/kilogram
µg/m^3	-	Micrograms/cubic meter
µm	-	Micrometer
USAEC	-	U.S. Army Environmental Center
XRF	-	X-ray fluorescence

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1.0 PURPOSE AND ORGANIZATION OF DOCUMENT

There is a growing national concern about the effects of lead exposure on human health and the environment. The demolition of whole structures containing lead-based paint (LBP) is a potential source of lead exposure that requires understanding and warrants a management protocol to minimize threats to human health and the environment. This draft technical report has been prepared to aid the U.S. Environmental Protection Agency (EPA) Region I in the development of a protocol for management of whole-structure debris containing LBP. Management includes sampling, analyzing, handling, recycling, burning, treating and disposing. This draft report meets the requirements of work assignment number R01031, under EPA contract number 68-W9-0002.

A discussion of the research and analysis performed to date by CDM Federal is presented in this report. This document represents a "snap-shot" in time of the state of the issues. With this information, draft protocols are recommended.. It is anticipated that these findings and recommendations will serve as a foundation which stimulates further discussion and research on the subject, which will ultimately lead to final EPA protocols.

This report is specifically limited to LBP debris generated from demolition of whole structures. It mentions, but does not focus on, LBP abatement wastes, debris generated during remodeling or renovation of structures, or LBP that has migrated from its original surface and become a contaminant in neighboring soils or surface waters. These are all important issues related to LBP and its impact on human health and the environment, but are beyond the scope of this document.

Various topics pertaining to the management of whole-structure demolition debris containing LBP are presented in this report. Background information, current regulations and practices, recommended protocols, and requirements for additional research and analysis are addressed. The organization of topics in specific sections follows:

- **Section 1 presents** the purpose and organization of the document.
- Section 2 summarizes the background issues regarding LBP and solid waste management.
- Section 3 presents background information on regulations and requirements pertaining to construction/demolition (C/D) debris containing LBP.
- Section 4 provides background information on the generation of C/D debris.
- Section 5 presents a comprehensive analysis of sample collection, including various protocols in current use, hypothetical sampling options, and recommended protocols

- Section 6 discusses sample analysis and presents recommended protocols
- Section 7 provides a discussion of management options for non-hazardous C D debris including landfilling, burning, and recycling. Recommended protocols are discussed
- Section 8 presents information on management requirements for hazardous C/D debris, including generator status, treatment, burning, recycling, and handling. Recommended protocols are provided.
- Section 9 discusses background information on lead exposure and presents available information on human health effects, environmental effects, and fate and transport, including lead leachability from landfills and combustion ash and lead air emissions.
- Section 10 recommends draft protocols for four important topics: sample collection, sample analysis, management of non-hazardous C/D debris, and management of hazardous C/D debris.
- Section 11 provides recommendations for continued progress in evaluating these issues. Recommendations in the following areas are provided: technical, regulatory, and economic. Status summaries for ongoing studies are presented.

2.0 BACKGROUND

2.1 BACKGROUND OF LEAD-BASED PAINT PROBLEM

Historically, many different types of paint used in the United States have contained as one of their components lead or a leaded compound, such as lead oxide or lead chromate. The former was used in white paint and the latter in red paint, chiefly used as a primer. Lead was a major ingredient in many types of house paint for years prior to and through World War II. In the early 1950s, other pigment materials became more popular, but lead compounds were still used in some pigments and as drying agents. Lead-based paint (LBP) is found throughout this country inside and outside of homes and buildings, on structures such as bridges and water storage tanks, and on products sold in the marketplace. LBP may eventually migrate from its intended surface, and may be inhaled or ingested by humans, posing to them a health hazard. While the sources of lead, such as gasoline and water systems using lead pipes or lead-based solder in copper piping systems, have been significantly reduced in recent years, the LBP in older structures remains a significant problem.

Federal regulatory efforts regarding LBP began with the enactment of the Lead-Based Paint Poisoning Prevention Act (LBPPPA) in 1971. In 1973, the Consumer Product Safety Commission (CPSC) established a maximum lead content of 0.5 percent by weight in a dry film of paint newly applied. In 1978, the CPSC lowered the allowable lead level in paint to 0.06 percent.

In October of 1991, the Centers for Disease Control (CDC) lowered the blood-lead level "level of concern" standard to 10 micrograms of lead per deciliter of blood, and estimated that 3 million U.S. children have lead concentrations above this danger level. The U.S. Environmental Protection Agency (EPA) estimates that one out of six American children under the age of six has elevated lead levels in the blood. As a result of this problem, the Clinton Administration is seeking a 70 percent increase, to nearly $35 million dollars for the 1994 fiscal year, in spending on lead pollution programs at EPA, and has launched a public information campaign to prevent lead poisoning. (*Washington Post*, May 5, 1993) The Agency for Toxic Substances Disease Registry (ATSDR) estimates that 42 million homes contain LBP, affecting 12 million children. (U.S. HUD, 1990) Americans are expected to spend $234 million on projects involving abatement of lead this year. (*New York Times*, March 21, 1993)

In the 1970s, the principal hazard to children was thought to be paint chips containing lead, primarily found in homes with peeling paint. Research in the early 1980s showed, however, that lead dust is of special concern, in part because the smaller particles are more readily absorbed by the body, and in part because the common methods of paint removal, such as sanding, scraping and burning, create excessive amounts of dust. Interior LBP dust can also come from normal abrasion of painted surfaces, such as the opening and closing of windows. Lead dust is especially hazardous to young children because they play on the floors where dust settles, and engage in a great deal of hand-to-mouth activity.

Lead dust from exterior paint is also a problem. For many years, exterior paint films were designed to "chalk," or lose some of the surface paint due to rain and ultraviolet light, in order to keep the surface looking fresh. The lead pigment which washed off in this process accumulated in the soil around the house. Other sources of lead in soils include improperly performed exterior LBP abatement work and deposition of lead from gasoline. (U.S. HUD, 1990) Lead-contaminated soil poses a hazard to children playing in or near it, and dirt tracked indoors can lead to increased lead dust levels in the home.

While adults may suffer various ailments due to excessive lead exposure, the groups most at risk from exposure to lead are fetuses, infants, and children under six. Excessive blood-lead levels can seriously damage a child's brain and central nervous system. Lead poisoning in children can cause attention span deficits, impaired hearing, reading and learning disabilities, delayed cognitive development, reduced IQ scores, mental retardation, seizures, convulsions, coma, and even death. In adults, high blood-lead levels may increase blood pressure and have other effects. (U.S. HUD, 1990)

2.2 OVERVIEW OF SOLID WASTE MANAGEMENT ISSUES

Despite the human health problems associated with LBP, it is typically a relatively minor component of most building demolition projects which generate construction and demolition (C/D) debris. Therefore, the majority of LBP C/D debris will not be managed as a hazardous waste. Methods for its management should be consistent with the solid waste management goals set by EPA, and should include source reduction, recycling, and combustion as preferential to landfilling.

2.3 OVERVIEW OF LBP ISSUES

There is a need for nationwide consistency with respect to the management of whole-structure demolition debris containing LBP. A protocol should be developed that is environmentally beneficial, protects human health, is enforceable, and promotes proper management. While a large percentage of the debris may contain LBP, the majority of the debris is expected to be non-hazardous because it is not a listed waste and does not exhibit a hazardous characteristic.

The quantities of C/D waste reported in various locations across the nation vary widely, ranging from 0.12 to 3.52 pounds per capita per day (pcd). A 1988 EPA Report to Congress on solid waste disposal estimated approximately 31.5 million tons per year of C/D waste based on an average generation rate of 0.72 pcd. (EPA, 1988) However, more recent studies have suggested that this value is underestimated and that it is not possible to reliably estimate C/D generation rates due to the large number of variables associated with C/D waste generation. In fact, in the 1990 and 1992 updates of the EPA report Characterization of Municipal Solid Waste in the United States, C/D generation rates were not included by Franklin Associates because there are no dependable figures or disposal practices at the national level. (Lambert, 1992) Some of the factors that make estimation difficult include the following:

- population and employment in the area
- the overall level of economic activity
- the extent of road- or bridge-related construction, renovation, and demolition
- extraordinary projects such as urban renewal, hurricanes, storm damage, fires or disasters
- records of actual C/D disposal at landfills and other disposal sites
- past and future trends in C/D activity. (C.T. Donovan, 1990b)

Due to concerns about occupational exposure to lead, the Occupational Safety and Health Administration (OSHA) promulgated an interim final regulation on May 4, 1993 requiring that demolition contractors and others place greater emphasis on programs designed to minimize and prevent occupational exposure to lead. The effective date of this regulation was June 3, 1993. Training programs, medical surveillance, respiratory protection, equipment and personnel decontamination, and exposure monitoring must be addressed during the performance of any work involving the disruption of surfaces which may result in the generation of airborne lead concentrations. The new regulation will require serious behavior modifications for contractors and contractor employees alike.

Currently, LBP debris generated from C/D projects is not managed consistently throughout the country. This is due in large part to an absence of established protocols for sampling the debris, and to a lack of knowledge that the material being generated may in fact be hazardous. As a result, this material is currently being either burned as an energy source or landfilled (without pretreatment). Burning can generate revenue for the contractor responsible for the demolition, and landfilling in either municipal solid waste (MSW) landfills or C/D landfills is a project cost. Managing the LBP debris as a hazardous waste is a much higher project cost and is therefore not often considered as an option. This approach is not in compliance with hazardous waste regulations.

Several demolition contractors have stated that demolition is not economically viable without the revenues generated from the sale of materials for either recycling or burning as an energy source. The economics of demolition projects will change significantly if some C/D debris containing LBP is determined to be a hazardous waste, requiring more costly methods for management, transportation, treatment, storage, and disposal. Potential adverse results include decisions to continue to use buildings previously planned for demolition. Such use will leave LBP in place, both in and on buildings, where it will continue to pose a health risk to those children and adults within the building, or nearby. (Spittler, 1992)

The demolition industry fears that new regulations will over-regulate LBP making it the "asbestos of the 90s." Over-regulation may close all avenues to recycling and reuse and increase demolition costs considerably. With promulgation of new regulations, perceptions about LBP risks could further increase. This perception change could have a significant impact that closes doors to recycling and municipal landfill disposal. (Taylor, 1992) Currently, the lack of C/D capacity in landfills and the cost of legal disposal has led to increased incidents of illegal dumping activities throughout the northeast U.S. (Lambert, 1992) These problems could contribute to increased risks to human health and the environment from debris containing LBP. EPA Region I is aware of these potential ramifications and has commissioned this report to investigate the issues and recommend protocols for management of whole-structure debris contaminated with LBP.

EPA's integrated solid waste management strategy stresses source reduction, recycling, combustion, and landfilling as the ordered hierarchy of waste management options. Because C/D debris containing LBP already exists in the form of whole structures awaiting demolition, the method to achieve source reduction is limited to effective waste identification and segregation. Recycling and burning are two management options with significant potential for C/D debris containing LBP. The last alternative, landfilling, is the least preferred option for non-hazardous debris.

3.0 REGULATIONS AND REQUIREMENTS CONCERNING LBP DEBRIS

3.1 OVERVIEW

Regulation of waste management within the United States begins at the federal level with the Resource Conservation and Recovery Act (RCRA). The aspects of RCRA relevant to lead-based paint (LBP) debris management are: (1) hazardous waste management, Subtitle C; and (2) solid waste management, Subtitle D. Additional aspects of federal regulations pertaining to waste management include the health and safety of workers, as regulated by the Occupational Safety and Health Administration (OSHA); the impact of waste burning on air quality, as regulated by the Clean Air Act; and regulations specific to buildings managed by the U.S. Department of Housing and Urban Development (HUD). Regulations promulgated at the federal level may be made more strict by the individual states, and states may also promulgate regulations where none exist at the federal level, as discussed in Section 3.3. Section 3.4 discusses additional conditions that commercial waste handlers may impose on their customers.

Under RCRA, waste generators are required to determine whether or not their waste is a hazardous waste. If it is a hazardous waste, the waste must be transported by a RCRA-permitted transporter to a RCRA-permitted treatment, storage and disposal facility. The management of hazardous wastes is outlined in Subtitle C of RCRA, and is discussed in Section 3.2.1 of this report. If the waste is determined not to be a hazardous waste, it is not as stringently regulated and is managed under Subtitle D of RCRA, as discussed in Section 3.2.4.

3.2 FEDERAL REGULATORY REQUIREMENTS

3.2.1 RCRA SUBTITLE C

Subtitle C of RCRA governs the management of hazardous waste. The regulations specifically detail how to determine whether a waste is hazardous, and once this determination is made, how to legally transport, treat, store and dispose of the waste. This section presents a hazardous waste regulatory overview; hazardous waste management issues are discussed in Section 8.0.

Generators of waste are required, under 40 C.F.R. Part 262, to identify whether or not their waste is a hazardous waste, using the criteria defined in 40 C.F.R. Part 261. If the waste is hazardous, it must be transported according to 40 C.F.R. Part 263 to a treatment, storage and disposal facility. Generators must comply with the land disposal restriction requirements found at 40 C.F.R. Part 268.

3.2.1.1 Hazardous Waste Determination

Under RCRA, a waste is hazardous if it is either a listed hazardous waste or if it exhibits one of the four characteristics (ignitability, corrosivity, reactivity and toxicity) of a hazardous waste. Upon reviewing the criteria in 40 C.F.R. Part 261, it can be determined that LBP demolition debris is not a listed hazardous waste nor is it excluded from regulation.

LBP debris is subject to evaluation against the RCRA hazardous waste characteristics, including the toxicity characteristic. The generator of the waste is responsible for making this determination. A generator may make this determination based either on knowledge of the material used in the waste or the results of the Toxicity Characteristic Leaching Procedure (TCLP). Generators should retain records to support both hazardous and non-hazardous waste determinations they make, since the generator is liable for civil penalties and other sanctions if the waste is improperly classified.

3.2.1.2 Toxicity Characteristic Leaching Procedure

The Toxicity Characteristic Leaching Procedure is intended to simulate the conditions that hazardous waste is exposed to in a landfill. The U.S. Environmental Protection Agency (EPA) developed the regulatory levels for hazardous constituents using health-based concentration thresholds and dilution/attenuation factors specific to each chemical. A concentration threshold indicates how much of the chemical adversely affects human health, while the dilution/attenuation factor indicates how easily the chemical could [illegible]p or leach into groundwater. The level set for lead was determined by multiplyin[illegible] health-based number by a dilution/attenuation factor of 100.

TCLP is an analysis performed on an extract from a representative sample of the waste. If the extract from LBP debris contains lead contaminants at the concentration equal to or greater than 5.0 mg/L, the waste is hazardous for the toxicity characteristic of lead. For a further discussion of this testing procedure, refer to Section 6.0.

3.2.1.3 Land Disposal Restrictions

<u>NOTE</u>: The following discussion presents a brief summary of the select subset of the Land Disposal Restrictions (LDRs) as they apply to hazardous debris exhibiting the toxicity characteristic for lead. The reader should refer to 40 C.F.R. Part 268 for a complete description of all applicable LDR requirements.

Background: The 1984 Hazardous and Solid Waste Amendments (HWSA) [illegible] EPA to develop regulations that would impose, on a phased schedule, treatment standards for listed and characteristic hazardous wastes prior to their land disposal. EPA developed the treatment standards (either specific concentration levels or methods of treatment) that substantially diminish the toxicity of wastes or reduce the likelihood that hazardous constituents from wastes will migrate from the disposal site. These treatment standards and applicable regulations are found at 40 C.F.R. Part 268, Land Disposal Restrictions (LDR).

Land disposal includes any placement of hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, salt bed formation or underground mine or cave. The reader should note, however, that regardless of where the waste is being sent (landfill, recycler, incinerator, etc.), generators must prepare the applicable LDR notifications and/or certifications to accompany the waste.

Prohibition of Land Disposal of Hazardous Debris: 40 C.F.R. Section 268.35(e)(1) prohibits the land disposal of hazardous debris, effective May 8, 1993. On May 14, 1993, EPA amended the prohibition effective date to May 8, 1994. 58 *Federal Register* 28506 provides a complete discussion on why the extension was granted and sets out the legal requirements that a generator must meet to benefit from this extension. These requirements include documenting good-faith efforts to locate treatment capacity for this waste stream and, to the extent that treatment capacity for this waste stream is available during the extension period, it must be used.

Hazardous Debris Treatment Standards: The treatment standards for hazardous debris were published in the *Federal Register* (*FR*) on August 18, 1992 and codified at 40 C.F.R. Section 268.45. (See 57 *FR* 37194-37282). Hazardous debris that is contaminated with a listed hazardous waste or that exhibits a hazardous characteristic must be treated prior to land disposal, using specific treatment technologies that either extract, destroy or immobilize the hazardous contaminants in/on the debris. The rule defines both the terms debris and hazardous debris. (The requirements for managing non-hazardous debris are discussed at Section 3.2.4). The definitions are:

> "*Debris* means solid material exceeding 60 mm (2.5 inch) particle size that is intended for disposal and that is: 1) a manufactured object; or 2) plant or animal matter; or (3) natural geologic material. However, the following materials are not debris: 1) any material for which a specific treatment standard is provided in Subpart D, Part 268; 2) process residuals such as smelter slag and residues from the treatment of waste, wastewater, sludges, or air emission residues; and 3) intact containers of hazardous waste that are not ruptured and that retain at least 75% of their original volume. A mixture of debris that has not been treated to the standards provided by 40

C.F.R. Section 268.45 and other material is subject to regulation as debris if the mixture is comprised primarily of debris, by volume, based on visual inspection" (40 C.F.R. Section 268.2(g)).

"*Hazardous Debris* means debris that contains a hazardous waste listed in Subpart D of Part 261, or that exhibits a characteristic of hazardous waste identified in Subpart C of Part 261" (40 C.F.R. Section 268.2(h)).

Examples of solid construction and demolition (C/D) materials that are debris, if intended for discard and if their particle size is 60 mm (2.5 in.) or greater, include: wood, sheetrock, glass, concrete (excluding cementitious or pozzolanic stabilized hazardous waste), masonry and refractory bricks, non-intact containers (e.g., crushed industrial equipment), tanks, pipes, valves, appliances, or industrial equipment; scrap metal (as defined in 40 C.F.R. Section 261.1(c)(6)); tree stumps and other plant matter; rock (e.g., cobbles and boulders); and paper, plastic, and rubber.

Although EPA is classifying mixtures that are predominantly debris as debris, this does not mean that debris can be deliberately mixed with other waste in order to change the treatment classification. Such mixing is impermissible dilution under 40 C.F.R. Section 268.3, since it is a substitute for adequate treatment. In addition, in such situations where debris is used merely to dilute the prohibited waste, the mixture would remain subject to the most stringent treatment standard of any waste that is part of the mixture.

EPA has specified 17 Best Demonstrated Available Technologies (BDAT) to treat hazardous debris, with the choice of technology left up to the generator and/or treater managing the waste. BDAT includes one or more of the following families of debris treatment technologies: extraction, destruction, or immobilization. The treatment must be conducted according to specified performance and/or design and operating standards. If the debris is treated to LDR standards using an approved extraction or destruction technology, the waste will not have to be managed as a hazardous waste, as long as it no longer exhibits any hazardous characteristics; however, if the debris is merely immobilized, the contaminants remain with the debris, and the immobilized debris must continue to be managed as a hazardous waste.

In summary, it is the responsibility of the generator of the LBP C/D debris to sample the waste to determine whether it is hazardous, by submitting it for TCLP analysis. If the waste fails the TCLP test, the debris must be managed as hazardous waste. If the waste is to be landfilled, it must be treated to regulatory standards before landfilling. If an extraction or destruction treatment method is used, and subsequent TCLP testing shows the material is no longer hazardous, then the material may be managed as non-hazardous waste. If the material is still hazardous it will require further treatment. If extraction and destruction technologies fail the debris will require immobilization treatment and subsequent disposal as a hazardous waste in a Subtitle C landfill. Residuals generated by the treatment of hazardous debris are subject to the LDR determination and management for the constituent which caused the debris to be contaminated.

3.2.1.3 Household Hazardous Waste Exclusion

Currently, wastes generated during the construction, remodeling or demolition of a household are not subject to the household hazardous waste exclusion, discussed below.

The regulations at 40 C.F.R. Section 261.4(b)(1) state that waste generated at a household is excluded from regulation as a hazardous waste. The Agency has stated that household waste has to be generated by individuals in their homes and the waste stream must be composed primarily of materials found in the waste generated by consumers in their homes. (49 *FR* 44978, November 13, 1984). EPA does not distinguish between waste generated by a homeowner and waste generated at a household by a person other than the homeowner. (54 *FR* 12339, March 24, 1989).

EPA has previously determined that lead-contaminated paint chips resulting from stripping and re-painting of residential walls by a homeowner or contractor (as part of routine household maintenance) would be part of the household waste stream and not subject to RCRA Subtitle C regulations. EPA Monthly Hotline Report, March 1990, Question 6.

EPA's current interpretation of the scope of the household waste exclusion states that any wastes generated at a household from building construction, renovation, and demolition, with the exception of those wastes generated from routine residential maintenance, are solid wastes subject to the requirements established under RCRA. (49 *FR* 44978, November 13, 1984). EPA Headquarters' Office of Solid Waste is currently revisiting this issue. Any change to the current interpretation will be publicized by EPA.

3.2.1.4 Recycle Scrap Metal Exception

Hazardous wastes that are recycled are subject to the requirements for generators, transporters, and storage facilities of 40 C.F.R. Section 261.6. However, scrap metal that is recyclable is not subject to hazardous waste regulation under the following parts of RCRA regulations: 40 C.F.R. Parts 262, 263, 264, 265, 266, 268, 270 and 124, and 3010. Tanks, equipment, ductwork, I-beams, and other scrap metal demolition debris that is recyclable may be affected by this exception.

3.2.2 CLEAN AIR ACT

Inhalation of lead, either from dust or an emission from a facility, is an exposure of concern to human health and the environment. Because of this concern, the amount of lead allowable in the atmosphere is regulated. The regulatory basis for air pollution abatement in the United States is the 1993 Clean Air Act (CAA) and its amendments. The CAA provides for two kinds of national ambient air quality standards. Primary ambient air quality standards are those requisite to protect public health with an adequate margin of safety. Secondary ambient air quality standards specify a level of pollutant concentrations requisite to protect the public welfare from any known or anticipated adverse effects associated with the presence of such air pollutants in the air. Secondary standards are based on damage to crops, vegetation, wildlife, visibility, climate, and on adverse effects to the economy. Thus an air quality standard is a level to which a pollutant concentration should be reduced to avoid undesirable effects.

The Clean Air Act requires each state to adopt a plan that provides for the implementation, maintenance, and enforcement of the national air quality standards. Emission reductions will abate air pollution, therefore the states' plans must contain legally enforceable emission limitations, as well as schedules and timetables for compliance with such limitations. The control strategy must consist of a combination of measures designed to achieve the total reduction in emissions necessary for the attainment of the air quality standards.

Currently, the CAA's primary and secondary standards require that not more than an average of 1.5 $\mu g/m^3$ of lead may exist in the atmosphere averaged over a 90-day period. Furthermore, lead emissions may also be a component of respirable particulate matter in the atmosphere. Currently, not more than 450 $\mu g/m^3$ of particulate matter less than 10 μm (dust small enough to be inhaled into the deepest portion of the lungs) may be in the atmosphere, averaged over an eight-hour workday. Based on these criteria, dust emissions on demolition projects and stack emissions from burning facilities are regulated for lead, and therefore are LBP issues.

3.2.3 OSHA

Regulations designed to protect and promote maximum employee and environmental health and safety protection for construction projects involving potential exposures to lead are still in regulatory evolution. A few states, such as Maryland and Massachusetts, have enacted legislation which effectively mirrors the general industry lead standard issued by the Occupational Safety and Health Administration (OSHA, 29 C.F.R. Section 1910.1025), for application in construction projects, such as demolition, structure renovation, and LBP abatement. The Lead-Based Paint Hazard Reduction Act, adopted in 1992, directed OSHA to enact an interim standard to address the health and safety issues involved with potential lead exposures during construction activities.

An interim final rule published on May 4, 1993 with an effective date of June 3, 1993 amends the OSHA standards concerning employee protection requirements for construction workers exposed to lead (29 C.F.R. Section 1926.62). All construction work excluded from coverage in the general industry standard for lead by 29 C.F.R. Section 1910.1025(a)(2) is covered by this standard. Construction work is defined as work for construction, alteration and/or repair, including painting and decorating. It includes but is not limited to the following:

1 Demolition or salvage of structures where lead or materials containing lead are present.

2 Removal or encapsulation of materials containing lead.

3 New construction, alteration, repair, or renovation of structures, substrates, or portions thereof, that contain lead, or materials containing lead.

4 Installation of products containing lead.

5 Lead contamination/emergency cleanup.

6 Transportation, disposal, storage, or containment of lead or materials containing lead on the site or location at which construction activities are performed.

7 Maintenance operations associated with construction activities.

In light of this interim final rule, demolition contractors must place greater emphasis on programs designed to minimize and prevent occupational exposure to lead. Training programs, medical surveillance, respirator protection, equipment and personnel decontamination, and exposure monitoring must be addressed during the performance of any work involving the disruption of surfaces which may result in the generation of airborne lead concentrations. The new regulations will require serious behavior modifications for contractors and contractor employees alike.

Prior to the promulgation of this interim final rule, agencies and organizations have required limited degrees of worker protection during abatement. The HUD Abatement Guidelines specify worker safety requirements for HUD sites. Other agencies, such as Rocky Mountain Arsenal and the U.S. Army Environmental Hygiene Agency, require that site-specific health and safety plans be developed for their facilities. The Denver Housing Authority requires the use of protective suits and respirators during cutting operations These guidelines will likely be supe[illegible]ed by the new OSHA regulation.

3.2.4 RCRA SUBTITLE D

Subtitle D of RCRA establishes a framework for federal, state, and local government cooperation in controlling the management of non-hazardous solid waste. The federal role in this arrangement is to establish the overall regulatory direction by providing minimum nationwide standards for protecting human health and the environment, and to provide technical assistance to states for planning and developing their own environmentally sound waste management practices. The actual planning and direct implementation of solid waste programs under Subtitle D, however, remain largely state and local functions.

Under the authority of Sections 1008(a)(3) and 4004(a) of Subtitle D of RCRA, EPA first promulgated the Criteria for Classification of Solid Waste Disposal Facilities and Practices, regulations found in 40 C.F.R. Part 257, on September 13, 1979. These criteria establish minimum national performance standards necessary to ensure that "no reasonable probability of adverse effects on health or the environment" will result from solid waste disposal facilities or practices. Section 1008 directs EPA to publish guidelines for solid waste management, including criteria that define solid waste management practices that constitute open dumping and are prohibited under Subtitle D. Section 4004 further requires EPA to promulgate regulations containing criteria for determining which facilities are open dumps, or those that fail to satisfy any of the Criteria.

On October 9, 1991, EPA promulgated revisions to 40 C.F.R Part 257, and added Part 258. These revisions were passed in response to HSWA. Part 258 sets forth revised minimum federal criteria for municipal solid waste (MSW) landfills, including location restrictions, facility design and operating criteria, groundwater monitoring requirements, corrective action requirements, financial assurance requirements, and closure and post-closure care requirements. amendments to Part 257 were made to make it consistent with the new Part 258. N monofills are not specifically defined under RCRA; however, C/D wastes co-dispos[illegible] household waste will be regulated under Part 258.

The effective date of Part 258 is October 9, 1993. MSW landfills that receive wastes on or after that date must comply with all requirements (with the exception of the Financial Assurance requirements effective April 9, 1994) or they will be considered open dumps which are prohibited. Existing MSW landfills that do not meet specific requirements (e.g., pertaining to flood plains, unstable areas, airports, and other requirements) have been given phased closure dates through October 9, 1996. The enactment of these regulations, which may require significant improvement to some MSW landfills, will likely result in a reduction in MSW landfill capacity.

3.3 STATE REGULATORY REQUIREMENTS

Below is a summary of information regarding individual states' waste management practices for C/D debris. Definitions of solid waste and C/D waste vary widely from state to state, as do the requirements for permitting a C/D waste processing facility. This information is current as of May, 1993 and readers should contact state agencies due to the dynamic state of this issue.

3.3.1 NEWMOA STATES

The Northeast Waste Management Officials' Association (NEWMOA) is a non-profit interstate association whose membership is composed of the hazardous and solid waste program directors for state environmental agencies in Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York (hazardous waste only), Rhode Island, and Vermont. NEWMOA was established by Governors in the New England states to serve as an official interstate regional organization. An overview of NEWMOA state C/D generation rates, definitions of C/D waste, requirements for wood reuse, and C/D landfill requirements is included in Table 3-1. This table was taken from a recent study developed for NEWMOA. The report is entitled Construction and Demolition Waste Disposal: Management Problems and Alternative Solutions, and was finalized in December, 1992.

3.3.1.1 Connecticut

"Bulky" waste is defined as "landclearing debris and wastes resulting directly from demolition activities other than clean fill." Bulky wastes are classified as special wastes which require special handling compared to other non-hazardous solid wastes. "Clean fill" is defined as "natural soil, rock, brick, ceramics, concrete, and asphalt paving fragments which are virtually inert and pose neither a pollution threat to ground or surface waters nor a fire hazard." Areas which are solely for the disposal of clean fill are exempt from the provisions of the regulations governing solid waste facilities. (CT Regulations Chapter 446d, Section 22a-209)

Transporters of bulky wastes are not required to have a special permit. Disposal at bulky waste landfills is limited to bulky waste because the cover frequency and groundwater separation distance are less than for MSW landfills. (CT Regulations Chapter 446d, Section 22a-209) However, bulky wastes may be commingled with municipal solid wastes at MSW facilities.

TABLE 3-1
NEWMOA STATES C/D DEBRIS MANAGEMENT SUMMARY

	Connecticut	Maine	Massachusetts	New Hampshire	New Jersey	Rhode Island	Vermont
/D Generation ates (Tons/Yr.)	0.3 - 0.45 tons/person/yr	156,000	2,400,000	101,260	4,500,000	20,000	490,000
finition for C/D & Other quirements	C/D or "bulky" waste is nonhazardous solid waste which requires special handling. Excluded from bulky wastes are clean fill (e.g., natural soil, rock, brick, ceramic, concrete, asphalt fragments) C/D LFs must comply with same siting reg. MSW LFs. Commingling ... allowed with MSW No hauler license required to transport C/D waste CT DOT allows use of clean fill material as subsurface mixture for roadways	C/D waste is from construction, remodeling, repair and demolition of structures, including building material, asphalt, wall board, pipe, mattresses, wire, and cable Does not include asbestos or other special waste "Inert fill" is rocks, brick, ...ed concrete ME DEP requires haulers of C/D to obtain license to transport.	C/D waste is building material and rubble resulting from construction, remodeling, repair or demolition of buildings, pavements, roads or other structures and includes concrete, bricks, lumber, masonry, road paving material, rebar, and plaster Same siting and design requirements for C/D as MSW LFs. Requires that C/D waste be recycled, if possible Demolition disposal license required by local government to ensure proper disposal requirements are met. No hauler license required to transport C/D waste	C/D waste is non putrescible waste building materials and rubble which is solid waste resulting from the construction, remodeling, repair or demolition of structures and roads. - C/D debris includes brick, concrete, other masonry materials, wood, wall coverings, plaster, dry wall, plumbing, fixtures, non asbestos insulation or roofing shingles, asphaltic pavement, glass, plastics, electric wiring, and metals. - Each town required to provide site for C/D waste disposal. - No hauler license required to transport C/D waste - Burning of C/D waste other than wood and farm biomass is prohibited - Codisposal of MSW and C/D debris is permitted.	Demolition waste comes from razed buildings, factories, building structures, streets, roads, and fences Requires 50 percent of all MSW waste to be recycled by 1995 for each municipality and 60 percent to be recycled for each county - Operating permits issued by NJ DEPE for transport and disposal of C/D waste Haulers of MSW and C/D waste required to register with NJ DEPE. NJ DOT allows C/D concrete, brick, asphalt and stone to be used in subsurface mixtures on roadways.	C/D waste is solid waste generated from the razing of buildings and other built structures - Currently all landfills are unlined. New draft regulations require double liners and leachate collection systems for MSW landfills but not for C/D landfills - C/D is allowed to be commingled with MSW	C/D waste is defined as non recyclable waste from building material, road re... and bulky vegetation and includes wood, plaster, sheetrock, rolled asphalt roofing, roofing shingles, insulation, flooring, brick, masonry and mortar, glass, soil and stone, and metal. Also shredded tires with written approval of VT DEP Division of Solid Waste Management
od Reuse	No treated, stained, glued, painted or pressure treated wood - Only virgin wood can be used as mulch for land application, highway grading, roadway beautification.	Stump wood chips can be spread on construction site. All other wood waste must be burned in combustion or waste-to-energy facilities.	Virgin wood material allowed to be chipped and used for landscaping. All other wood waste must be burned in waste-to-energy facilities	- Wood chips used to fuel waste-to-energy facilities. No lead based chips allowed to be used in top soil additives. Virgin wood chips used as landscaping material.	Non-chemically treated demolition waste can be processed through chipping for reuse - Chemically treated or painted wood must be sent to state approved landfills or sent out of state for disp.	No specifics on wood chipping	No specifics on wood chipping
c Monitoring uirements C/D Landfills	Inspections GW & SW monitoring. No liner or leachate collection system for LFs Minimize leachate production through good operating practices	- No liner or leachate collection system required for less than 6 acre sites	Inspections GW & SW testing Same requirements as MSW landfills unless waiver granted	Require liner & leachate collection system. Same requirements as MSW landfills No separate disposal area required for C/D waste	GW & S... Same req... MSW landfills Haulers required to register Double liners required	C/D facilities are exempt from permitting process Review of design & site plan Updated regulations require MSW landfills to have liners & leachate collection systems C/D commingled with MSW Presently no liners required for landfill operations	C/D facilities required to be permitted and certified

While it is permissible to burn recycled wood (e.g., bulky wood waste, scraps, pallets) in permitted wood burning facilities, treated wood (e.g., painted, stained, glued, preserved) and demolition wood are excluded. (CT Regulations Chapter 446d, Section 22a-[illegible])

3.3.1.2 Maine

Maine defines C/D debris as debris resulting from "construction, remodeling, repair and demolition of structures," and includes but is not limited to "building materials, asphalt, wall board, pipes, metal conduits, mattresses, household furniture, fish nets, rope, hose, wire and cable, fencing, carpeting, and underlay." C/D debris does not include asbestos or other special wastes. Transporters of C/D waste are required to have a special license. (ME Regulation 06-096 Chapter 400)

Other wastes from demolition activities may be classified as "inert fill" which is defined as "soil material, rocks, bricks, and cured concrete which are not mixed with other solid or liquid waste and which are not derived from an ore mining activity." (ME Regulation 06-096 Chapter 400)

Maine regulations are identical for C/D debris and inert fill. If the landfill is smaller than six acres, neither liners nor leachate collection systems are required. For landfills greater than six acres, the regulations for MSW landfills apply. The regulations also allow the disposal of C/D debris on the same parcel of land where the waste was generated when the solid waste boundary encloses an area of less than one acre. (ME Regulations 06-096 Chapter 404)

3.3.1.3 Massachusetts

Massachusetts defines C/D debris as "building materials and rubble resulting from construction, remodeling, repair, or demolition of buildings, pavements, roads or other structures." C/D debris includes "concrete, bricks, lumber, masonry, road paving materials, rebar, and plaster." C/D landfills must comply with the same regulations as MSW landfills. The state also requires that C/D debris be recycled, if possible. The state licenses local government to ensure that proper disposal requirements are met. Transporters of C/D waste are not required to have a special license. (MGL 310 CMR 16)

C/D debris regulations in Massachusetts, New Jersey, and Maryland are among the most strict regulations in the country. Massachusetts is considering closing its MSW landfills to C/D wastes. (Taylor, 1992)

3.3.1.4 New Hampshire

New Hampshire defines C/D debris as "non-putrescible waste building materials and rubble which is solid waste resulting from the construction, remodeling, repair, or demolition of structures and roads." C/D debris includes but is not limited to "bricks, concrete, and other masonry materials, wood, wall coverings, plaster, dry wall, plumbing, fixtures, non-asbestos insulation or roofing shingles, asphaltic pavement, glass, plastics that are not sealed in a manner that conceals other wastes, electrical wiring, and components containing no hazardous liquid and metals that are incidental to any of the above." (NH RSA 149-M) Each town is required to provide a site for C/D waste. Burning of C/D waste other than wood and farm biomass is prohibited.

3.3.1.5 New Jersey

New Jersey defines demolition waste as "waste generated from razed buildings, factories and building structures, including streets, roads, and fences." (NJ Administrative Code Title 7 Chapter 26) Demolition wastes and construction wastes are both classified as bulky wastes. Operating permits are issued for transportation and disposal of C/D waste.

The New Jersey Recycling Act, passed in 1987, designates recovery targets for each municipality and each county to achieve the maximum feasible recovery of recyclable materials from the municipal solid waste stream. Each municipality has a target of 50 percent recycling by December 31, 1995. Each county has a target of 60 percent recycling by December 31, 1995. (NJSA 13:1E-99. 13.) C/D waste can be recycled and is included in county solid waste recycling plans. A number of processing facilities operate in New Jersey receiving source-separated non-chemically treated or painted wood waste, concrete, asphalt, brick, cinder block, asphalt-based roofing scrap, and stone. (Lambert, 1992b)

3.3.1.6 Rhode Island

Rhode Island defines demolition waste as "solid waste generated from the razing of buildings and other built structures." (RIGL. Section 23, Chapter 18.9) All Rhode Island landfills are currently unlined. Therefore new draft regulations require double liners and leachate collection systems for MSW. C/D debris is allowed to be commingled with MSW.

3.3.1.7 Vermont

Vermont defines C/D debris as "non-recyclable waste from building material, road rubble and bulky vegetation," which includes "wood, plaster, sheetrock, rolled asphalt roofing, roofing shingles, insulation, flooring, brick, masonry and mortar, glass, soil and stone, and metal." (VT Solid Waste Management Plan)

3.3.2 OTHER STATES

Other states outside of the NEWMOA consortium were also contacted for information. These states were selected based on previous involvement in LBP abatement issues. Comprehensive information on state waste management was not gathered; therefore, the following information is presented for general considerations.

3.3.2.1 Kentucky

Kentucky requires LBP debris testing only if there is reason to believe the waste is hazardous (as in the case of abatement wastes). If the TCLP results are above 5.0 mg/L for lead, the waste is hazardous. If the results are below 5.0 mg/L, but lead is still present, the waste is non-hazardous, but landfill operators may call it a special waste and charge more for its disposal. (Adams, 1992)

3.3.2.2 Maryland

Maryland has strict requirements regarding LBP based on volume; however, most abatements are residential and the volume of disposed debris does not fall under state regulations. (Wojtowycz, 1992) State regulations address limited demolition only, (e.g., replacing a window) and require testing of debris from nonresidential or multi-unit buildings (e.g., apartment buildings) for disposal as small quantity generators. Debris from single-family units is not required to be tested and is disposed in a municipal solid waste landfill. State regulations do not address full-scale demolition (e.g., wrecking ball or bulldozer). (Guyaux, 1992)

Regulations define lead-containing substances as paint, plaster, or other surface coating material containing more than 0.5 percent lead by weight calculated as lead material in the dried solid, or more than 0.7 mg/cm² by X-ray fluorescence (XRF). Waste disposal must comply with applicable hazardous waste regulations. (Maryland, 1988)

3.3.2.3 New York

In New York, waste disposal is conducted in accordance with applicable solid or hazardous waste regulations depending on waste identification. Some state regulators are concerned that the large number of HUD and state agency abatement and demolition initiatives in the next five years will generate huge volumes of debris that will exceed available capacities of hazardous waste disposal facilities. A suggested approach is to handle the debris as a universal waste with disposal in Subtitle D facilities in compliance with Part 258 regulations. H[illegible] this approach is contingent upon a federal determination that the debris can be classified as a universal waste (Nadler, 1993)

3.3.2.4 Ohio

Ohio is in the process of developing C/D debris regulations, with new regulations currently on hold. C/D debris is currently exempt from solid waste regulations and is only regulated through the state's air pollution program. Some local health departments are more strict than others about regulating LBP. (Odgen, 1992 and O'Connell, 1993)

3.3.2.5 Pennsylvania

Pennsylvania defines C/D wastes as "solid waste resulting from the construction or demolition of buildings and other structures, including, but not limited to, wood, plaster, metals, asphaltic substances, bricks, block and unsegregated concrete." The term does not include "uncontaminated soil, rock, stone, gravel, unused brick and block, and concrete" if they are separate from other waste and are used as clean fill. (PA Code Title 25, Chapter 271)

C/D wastes from residential, municipal, commercial, or institutional structures are regulated as municipal wastes. C/D wastes from industrial, mining, or agricultural structures are regulated as residual wastes that are handled as municipal wastes. If C/D waste is disposed in a MSW landfill or combusted in a MSW incinerator, no prior testing of the waste is required. Disposal of C/D wastes in unlined C/D landfills is infrequent and waste characterization is required. (Roof, 1993)

Reuse of C/D wastes is subject to the municipal solid waste approval process, which requires characterization. The state has recently made a determination that reuse of waste wood containing LBP as mulch is not permitted. (Roof, 1993)

3.3.2.6 South Carolina

The South Carolina Solid Waste Management Act of 1991 required the establishment of separate regulations for MSW, C/D, and industrial wastes. Regulations governing C/D landfills were promulgated on July 23, 1993 and define any waste in contact with LBP as unacceptable for disposal at C/D landfills. Liners are not required at new C/D landfills, hence the definition of certain wastes as unacceptable

Large quantities (e.g., dump truck loads) of wastes in contact with LBP are considered to be special wastes, and each MSW landfill must have an approved Special Waste Authorization and

Implementation Plan (SWAIP) if special wastes will be accepted at that facility. (Kenney, 1993) The provisions of the SWAIP typically include both hazard characterization by the generator and periodic verification by the MSW landfill operator. (Kenney, 1993) Small quantities of LBP debris (e.g., single pickup truck loads) generated by renovation or demolition of small structures (e.g., barn or tool shed) may be considered to be household waste and are not subject to generator characterization requirements. (Kenney, 1993)

The commercial burning of treated wood is allowed only at facilities permitted to dispose of hazardous waste, including cement kilns permitted under the Boiler and Industrial Furnace rule. (Kenney 1993) Homeowners may burn natural scrap wood, such as tree stumps, on the property where it was felled. However, wood products "made by man" can not be burned by private citizens. (Ohlandt, 1993)

3.3.2.7 Washington

Seattle is developing a construction waste recycling guide that discusses types of waste generated, available waste management facilities, and capacity limitations. In the Seattle area, none of the recycling facilities will accept wood containing LBP; it all goes to landfills. (Grave de Peralta, 1993)

3.4 COMMERCIAL FACILITY REQUIREMENTS

In addition to federal, state and local LBP debris requirements, commercial waste management facilities (e.g., landfills, treatment and recycling facilities, transporters) may require their customers to comply with additional conditions. Commercial facilities need sufficient waste analysis data to support technical waste management decisions and to avoid potential liability issues. (Knapp, 1993) Hence, these facilities may prescribe additional sampling and analysis requirements for LBP debris.

4.0 GENERATION OF C/D DEBRIS

4.1 SOURCES

Construction and demolition (C/D) debris containing lead-based paint (LBP) is generated by federal, state and local agencies, and by the private sector. Reliable data are not available to predict the quantity of LBP debris generated, to determine the portion of this debris that is amenable to recycling or burning, nor to determine the economic viability of demolition projects. The following limited information is available.

4.1.1 PRIVATE SOURCES

LBP is found in private residences located mostly in cities known as the "Lead Belt," which are older homes constructed in the early 1900s, mostly located in the northeast and midwest U.S. (Lambert, 1992) In the New England area, LBP was frequently used in the construction of utilities and interior/exterior finish of houses. Debris components include lead pipes, painted woodwork, furniture, utilities, and painted exteriors including siding, shingles, doors, and sashes. (Higgins, 1993) LBP is also found in newer structures, because paint containing high levels of lead was in widespread use through the mid-1970s. Large structures such as hotels are major sources of debris containing LBP.

Other private sources of debris containing LBP include industrial facilities such as factories, warehouses, mills, refineries, and other complexes undergoing renovation or demolition. These facilities will typically have higher percentages of non-permeable components such as tanks, drums, and structural steel that may be coated with LBP for rust-proofing. The high salvage values for these components make them strong recycling candidates.

4.1.2 STATE/LOCAL SOURCES

State and municipal facilities include properties such as civic buildings, hospitals, schools, and police and fire departments. Many of these facilities, together with public housing projects, are older, and are potential sources of LBP. State and local governments are under increasing financial pressure, and therefore have been selling properties as a means of generating additional revenues, the sale of which may include the demolition of unwanted buildings. Agir -ainted, nonpermeable structures that will require demolition are also common, such as bric water tanks and fuel tanks.

4.1.3 FEDERAL SOURCES

Federal facilities include civic properties, U.S. Department of Defense (DOD) properties and U.S. Department of Energy (DOE) properties. DOD properties are the major source of C/D debris, generated as a result of the Base Realignment and Closure (BRAC) which is reducing and eliminating existing military bases. As these bases are reduced, buildings are being demolished requiring disposal of the waste debris.

Sources of LBP at DOD facilities include painted military equipment, machinery, army barracks, and housing units. It has also been reported that excess ship paint, with high lead concentrations, not used on ships had been instead used on military hardware. The DOD also used extra battleship paint on government furniture through 1974 (Burkle, 1992). Other sources of LBP in military buildings can be found in glazed glass and window areas. The DOD estimates that billions of square feet of World War II barracks contain LBP.

DOE activities are another major federal source of demolition debris that may contain LBP. The decontamination and decommissioning of DOE facilities will generate large quantities of debris. Unlike residences and office buildings, manufacturing facilities contain debris types such as tanks and steel work. These less-permeable debris components are strong candidates for recycling due to their high salvage value.

4.2 TYPES AND QUANTITIES

The quantities of C/D waste reported in various locations across the nation vary widely, ranging from 0.12 to 3.52 pounds per capita per day (pcd). A 1988 U.S. Environmental Protection Agency (EPA) Report to Congress on solid waste disposal estimated approximately 31.5 million tons per year of C/D waste based on an average generation rate of 0.72 pcd. (EPA, 1988) However, more recent studies have suggested that this value is underestimated and that it is not possible to reliably estimate C/D generation rates due to the large number of variables associated with C/D waste generation. In fact, in the 1990 and 1992 updates of the EPA report Characterization of Municipal Solid Waste in the United States, C/D generation rates were not included by Franklin Associates because there are no dependable figures or disposal practices at the national level. (Lambert, 1992) Some of the factors that contribute to variability include the following:

- population and employment in the area
- the overall level of economic activity

- the extent of road- or bridge-related construction, renovation, and demolition
- extraordinary projects such as urban renewal, hurricanes, storm damage, fires or disasters
- records of actual C/D disposal at landfills and other disposal sites
- past and future trends in C/D activity. (C.T. Donovan, 1990b)

This significant rate of generation, coupled with the declining availability of landfill capacity, creates a growing disposal problem that can only be solved through recycling, reuse, and burning options.

It is estimated that C/D debris comprises 14 to 25 percent of the total waste stream in any given state, depending on the majority of the development density, urban or rural in makeup. (Fowler, 1991) The C/D wastes include discarded building materials and rubble from the construction renovation, repair and demolition of buildings, bridges, roadways, retaining walls, and other structures. (Lambert, 1992) Lead may be found in C/D waste sites receiving debris in areas (northeast, midwest) where the use of LBP was common until 1974.

A study on the composition of C/D waste in Vermont revealed that wood comprises 25.6 percent and metal comprises 5.1 percent of total C/D waste in the state. In Rhode Island, wood in C/D waste comprises 13.3 percent of total landfill waste. Table 4-1 presents the findings of the study. (Fehrs, 1993)

TABLE 4-1
WASTE COMPOSITION (PERCENTAGE) IN C/D DEBRIS

Waste Type	Vermont	Rhode Island
Metal	5.1	5
Wood	25.6	13.3
Asphalt	NR	47.1
Concrete	14.2	16
Ash	9.2	NR
Miscellaneous	45.9	18.6

Source: (Fehrs, 1993)

A waste composition study commissioned by the Toronto Works Department in 1991 evaluated the composition of demolition wastes and combined C/D wastes delivered to the local landfills. Recycling rates were not considered, and the data did not account for any material removed at the demolition site for recycling or reuse. The composition analysis is presented in Table 4-2.

TABLE 4-2

C/D WASTE COMPOSITION (PERCENTAGE) IN METRO TORONTO

Waste Type	Demolition Only	Combined C/D
Wood	51.8	34.8
Rubble, Aggregate, Ceramics	24.7	24.1
Building Materials	7.9	16.6
Ferrous Metals	4.7	7.3
Paper, Paperboard	0.7	7.8
Glass	0.0	2.8
Plastic	0.7	2.5
Fines	8.7	1.9
Miscellaneous	0.8	2.2

Source: Metropolitan Toronto Waste Composition Study, 1991 (excerpted in Gershman, 1992)

Note: All figures are based on percentage weight.

A major future source of demolition debris containing LBP will be deficient steel bridges requiring replacement. Based on the National Bridge Inventory, 185,928 of the 208,505 steel bridges carrying public roads are covered with LBP. Approximately 103,191 of the 208,505 bridges are classified as deficient and eligible to receive federal replacement funds. (Carlson, 1993)

5.0 SAMPLE COLLECTION

Sampling heterogeneous solid waste is an important step in evaluating disposal options for construction and demolition (C/D) debris. There are a variety of approaches currently in use for collecting representative samples so that appropriate management decisions can be made. In this section of the report, current approaches for sampling permeable components of buildings and demolition debris are summarized. Using these techniques, and incorporating knowledge of U.S. Environmental Protection Agency (EPA) sampling protocols for other types of media, this information is synthesized and expanded to evaluate the sampling options for permeable debris that will best produce quality representative data.

Section 5.1 presents the current approaches being used. Section 5.2 presents six hypothetical sampling approaches and compares the relative cost and confidence level of each hypothetical approach. The information presented in Section 5.1 and 5.2, current and hypothetical sampling approaches, respectively, was used to develop recommended sample collection protocols, which are presented in Section 5.3.

For the purposes of making hazardous or non-hazardous determinations regarding buildings and demolition debris, these sampling options assume no other hazardous materials are present (e.g., asbestos, polychlorinated biphenyls) and that lead-based paint (LBP) is the only "hazard of concern." It is also assumed that metal components of the structure (e.g., I-beams, piping, ductwork, siding, flashing, metal window frames) and any other non-permeable components will be segregated and recycled or reused for their salvage value. Therefore, this section will not address sampling these non-permeable components.

It is important to understand that, when developing sampling options for buildings and demolition debris, structures can vary widely, ranging from small and simple structures such as family dwellings to medium-sized structures such as office buildings, to large and more complex structures such as industrial facilities. Therefore, sampling protocols should be able to accommodate a wide variety of structures.

Data quality objectives (DQOs) are an important aspect of any sampling protocol and must be carefully reviewed prior to planning and executing a sampling event. When trying to determine sampling options, some of the following questions must be answered to clarify the DQOs:

1 What sample collection method should be employed to adequately characterize a building (containing components with LBP coatings) as a hazardous or non-hazardous waste?

2 Does that sample collection method result in data representative of the materials to be disposed or recycled after dismantling or demolition, which may include unpainted components as well as painted components?

3 Is that sample collection method cost-effective?

4 How will the sample be (physically) collected?

5 At what frequency (how many) should samples be collected?

6 Will the samples be composite or grab samples?

7 Will the location of the samples be selected randomly, by best professional judgement, or on a grid pattern?

8 What type of quality control samples should be collected and at what frequency?

The current analytical method being used to make hazardous or non-hazardous determinations for demolition debris is the toxicity characteristic leaching procedure (TCLP), which is discussed in Section 6.1. The TCLP method has a regulatory threshold of 5.0 mg/L for lead. It has been questioned by some whether or not the TCLP method is representative of actual landfill conditions for solid waste or demolition debris. (Rupp, 1992) Despite this question, the TCLP method is the prescribed analytical method at this time. For the purposes of this section, the reader should assume that TCLP will be the analytical method used and that the sample will be prepared according to the preparation technique required by the method or the laboratory.

5.1 CURRENT APPROACHES TO SAMPLING C/D DEBRIS

This section summarizes the available sampling techniques based on a comprehensive information gathering effort for this topic. Seven approaches to sampling LBP debris were identified as being in use or under development. Table 5-1 briefly compares and summarizes key factors associated with each method. A detailed discussion of each method follows.

5.1.1 U.S. ARMY ENVIRONMENTAL HYGIENE AGENCY

The U.S. Army Environmental Hygiene Agency (AEHA) developed a sampling protocol for building demolition debris and buildings painted with LBP in October of 1992. (AEHA, 1992) Problems associated with the disposal of construction debris, particularly debris "contaminated" with LBP, and the lack of specific regulatory guidance prompted the AEHA to develop their own sampling protocol. Development of this protocol was funded by the United States Army Environmental Center (USAEC) and AEHA is seeking "approval" of the protocol by EPA. (Hauschild, 1992) EPA's Office of Solid Waste and Emergency Response (OSWER) has

TABLE 5 - 1
COMPARISON OF KNOWN SAMPLING APPROACHES

Approach	Purpose	Sample Time	Sample Number	Sample Location	Collection Method	Other
AEHA	Developed for demolition debris. Specific for permeable lead-based painted construction material: wood, brick, cement and plaster/wall board.	Before Demolition.	Number of sample buildings is statistically determined. Single composite sample per building.	Randomly selected.	One-inch drill bit coring through entire substrate. Collect drill cuttings and dust in disposable sample container	Developed for numerous similar structures. Plan to use existing data in lieu of actual sampling because sufficient data is considered to be available
DHA	Developed for bulk material from lead abatement projects.	After Demolition.	One TCLP test per load of waste. (i.e., 6000 kg of waste).	All material removed from the abated structure.	Saw bulk material into pieces. Collect sawdust.	Methodologies may be applicable for demolition projects
RMA	Developed for no future use structures. Specific for porous materials only.	Before Demolition.	Up to 50 aliquots per composite sample.	Evenly spaced systematic grid w/uniformly sized aliquot grid sites.	Coring with carbide-tipped or diamond-tipped drill bits depending on sample matrix. Crushed using jaw crusher	Protocol supports a detailed analysis of alternatives for building cleaning or disposal of no future use structures
EPA Region VII	Developed for permeable matrices. Not specific for any contaminant.	Before and After Demolition.	Composite sample from building with an areal extent of 2,500 sq. feet.	Roof 10% Windowsills 10% Attic 10% Molding 10% Floors 20% HVAC 20% Exterior 10% Interior 10%	New 1/4-in drill bit for most components, 3/8-in carbide bit for concrete. Collect with hand-held vacuum.	Developed to determine alternatives for demolition and disposal of structures slated for no future occupancy
Independent L[illegible]tory	Disposal determinations of "whole-structure" debris.	After Demolition.	Non-specific (representative weighted sample).	Randomly selected.	Non-specific.	"Mass weights" the results to get representation of the entire structure
Demolition Contractor	Disposal determination.	Non-specific.	Non-specific.	Non-specific.	3/8-in. punch through entire substrate	90% exterior components for TCLP
CT DEP	Disposal determination of "whole-structure" debris	Before Demolition.	XRF reading of all painted surfaces.	Non-specific.	Based on portable XRF devices	Relies predominantly on portable XRF devices and estimates of painted surface and structure mass

reviewed and commented on AEHA's sampling protocol. While not officially approving or denying the protocol, OSWER agreed with many elements of AEHA's approach (EPA, 1[illegible]

AEHA's sampling protocol is based on characterizing a large number of buildings such as those at an Army base. AEHA looks at a "population" of similar buildings and statistically determines the number of buildings to be sampled from that population. The derived number of buildings are then randomly selected for sampling. The objective is to obtain from each selected building one composite sample which should consist of the appropriate proportions of all materials, both painted and unpainted, represented within the structure.

Non-permeable building components such as glass, screen, aluminum siding, metal duct work, and utility equipment are not sampled. These components are segregated and disposed separately or recycled. In general, the most commonly sampled components are those permeable matrices such as wood, brick, cement and plaster/wallboard that are likely to have LBP-coated surfaces.

Each homogeneous building component within the structure, both painted and unpainted, is then identified. The number of subsamples taken from each homogeneous building material is determined by the proportional surface area of the material based on estimated square footage. The total estimated areas of each homogeneous building material are then compared to one another in order to establish ratios. The ratios will determine the number of subsamples (volume of subsample material) to obtain from each individual area. Generally, 20 to 30 subsamples are necessary to make up one 110.0-gram sample (volume required for TCLP analysis).

Each subsample is collected using a one-inch drill bit by coring through the entire substrate (where feasible) and collecting the sampled material into a disposable container. After compositing, based on ratios defined by estimated surface area, sample material is transferred to a clean plastic bag, labelled and shipped to a certified analytical laboratory for TCLP analysis.

Analytical results are statistically analyzed to assess the variability among the structures and the overall normality of the lead distribution. If the analytical results do not indicate a normal distribution, AEHA transforms the data according to EPA guidance SW-846, November 1986, Test Methods for Evaluating Solid Waste (Volume II), 3rd Edition. After normality has been achieved through an appropriate transformation, the 80 percent confidence interval is calculated and compared to the regulatory threshold of 5.0 mg/L for lead, similarly transformed, as appropriate. Note that during their review of the AEHA protocol, OSWER indicated that data transformations are not recommended (EPA, 1993a) The AEHA agrees that data transformation may not be an entirely valid approach, however, the AEHA has also noted that even using a straight 80 percent confidence interval of the raw data is not statistically valid due to the non-normal data distribution. While neither approach may be entirely appropriate, the AEHA considers the use of transformations as acceptable if data normality can be achieved. (Hauschild 1993b) AEHA's interim final report presents data acquired using this protocol. The conclusions and recommendations from this interim final report are excerpted in Section 11.3.1

5.1.2 DENVER HOUSING AUTHORITY - DENVER, COLORADO

The Denver Housing Authority (DHA) determined the need to develop a procedure for sampling bulk materials removed from structures during LBP abatement procedures. Though the procedures developed were specifically designed for use in abatement projects, the methodologies may be applicable for demolition projects. As conveyed in a letter from DHA to the U.S. Department of Housing and Urban Development (HUD) Office of Public Housing, state hazardous waste regulations specifically state that "all material abated will be tested for toxicity by TCLP. All material reported to leach lead at [5.0 mg/L] or above is hazardous and will be treated and disposed of as such." (Ward, 1991b)

The DHA in conjunction with EPA Region VIII and the Colorado State Department of Health, Hazardous Waste Management, developed a procedure for TCLP testing of abatement wastes that in effect uses a load averaging method for sample collection. Note that this method applies to debris after abatement has occurred, in contrast to the AEHA approach, which samples whole structures prior to demolition.

The DHA method requires one TCLP test per load of waste (load equal to not more than 6,000 kilograms). EPA Region VIII recommended that DHA follow the sampling protocol similar to that used in mining waste, which requires the calculation of given proportions of the items contained in the load and reduction of the particle size so the material can be accurately measured and dissolved during the analytical process.

DHA's method requires that a cutting area be set up to saw bulk materials into pieces. DHA requires specific safety procedures for worker protection which vary depending on whether the cutting area is set up inside a building or outside. Bulk materials are segregated, and like items are placed together. The volume or weight of each group of items to be sampled is recorded. The items are cut into lengths using a circular saw. Sawdust from the cutting operation for each pile is collected and saved in sample containers (approximately 100 grams of each representative material is collected).

After calculating the percentage of each of the represented materials by weight or volume in the waste piles, the sawdust is measured using a graduated cylinder or glass beaker to correlate with recorded volumes or weights to get a properly proportioned sample. The measured sawdust from each material is placed in a sample container and submitted to a laboratory for TCLP analysis.

Other EPA reviewers have evaluated this approach. A representative from EPA Region I Environmental Services Division (ESD) agreed that this approach was "rational." (Spittler, 1992) A representative from EPA's Environmental Monitoring Systems Laboratory - Office of Research and Development (EMSL-ORD), Las Vegas, Nevada, agreed that in terms of obtaining a "meaningful" sample, DHA's approach was "not bad." (Vincent, 1992)

5.1.3 ROCKY MOUNTAIN ARSENAL - NO FUTURE USE STRUCTURES

Rocky Mountain Arsenal (RMA) - No Future Use Structures Sampling and Analysis Work Plan, prepared in July, 1991 by Greystone Environmental Services, Inc. (Greystone Environmental Services, 1991) presents options for sampling buildings based on history of use. Although this report does not specifically address LBP as a potential contaminant, this procedure is relevant for structure sampling protocols.

A panel of 12 accomplished specialists was assembled to provide guidance and support for RMA's effort. One assumption made by the panel was that the primary assessment criteria would include use of the TCLP (modified or expanded list) for ultimate disposal/remediation decisions. The panel devised a sampling protocol that assumed all process equipment and piping would be removed from the building prior to demolition due to no future use status. The RMA protocol is for porous materials only. Non-porous materials were not sampled as these materials tend not to absorb chemicals.

Multi-aliquot samples consisting of various structure matrices are collected on an evenly spaced systematic grid pattern (based on volume and excluding interior space) to provide representative composites of the matrices comprising that structure's interior. The approach involves subdividing structures into uniformly-sized aliquot grid sites of 10 cubic yards or less within a volume of 500 cubic yards or less. The grids are distributed throughout the entire structure's interior. Each 500-cubic-yard grid represents one composite sample. To collect a representative composite sample from the grid, each sampling grid is subdivided into 50 individual aliquot grid sites representing, at most, 10 cubic yards. An aliquot is collected from the interior of each aliquot site. Upon completion of sampling, aliquots are composited into a single sample containing a maximum of 50 aliquots. For each structure larger than 500 cubic yards, more than one composite sample is collected. For example, a structure which is 660 cubic yards in size is represented by two composite samples, each representing approximately 330 cubic yards. For structures which are less than 500 cubic yards, grid sizes are altered so that a minimum of 20 aliquots represent a composite sample (e.g., 1 aliquot grid site is less than 10 cubic yards).

Each sample matrix is physically collected using power drills with carbide-tipped drill bits and coring devices with diamond cores. The choice of tools is based on the depth and type of material within an individual structure and professional judgement of the sampling personnel. Collection of drill cuttings is accomplished by the use of a hand-held vacuum cleaner or an industrial-grade vacuum cleaner depending on the type of matrices being sampled and the required sample depth. The vacuum cleaner fiber filter (hand-held vacuum) or the vacuum cleaner bag (large vacuum) is dedicated to each composite sample and each aliquot matrix being collected to minimize the potential for cross-contamination. Aluminum baking pans, or equivalent, are utilized for the collection of drill cuttings from locations where a vacuum cleaner is not effective.

Concrete cores are crushed using a Jaw Crusher. Aliquots to be homogenized and composited are collected from the Jaw Crusher receptacle and placed within a plastic bag for homogenization and eventual compositing.

5.1.4 EPA REGION VII

A debris sampling method for permeable matrices was developed by EPA Region VII to determine alternatives for demolition and disposal of structures slated for no future occupancy. (Keffer, 1990a) An EPA Region VII staff member was also on the RMA panel of specialists and had significant input to the sampling technique developed for RMA. This method is not specific for LBP contamination.

As at RMA, multi-aliquot composites are collected by a powered hand drill and a portable vacuum. To ensure adequate sample volume, a range consisting of 20 aliquots (equal to no less than 4 ounces) to 50 aliquots (equal to no more than 8 ounces) is collected. Aliquot sample locations are collected at a frequency of 1 per 10 cubic yards (as debris) or 1 per 200 square feet (as built). Single composite samples are taken from structures with an areal extent of 2,500 square feet or less. For larger structures multiple samples must be collected. The optimal priority for distribution of aliquots is as follows:

Sample Matrix	Percent Distribution
Roof	10%
Window sills (exterior)	10%
Attic or crawl space structure members	10%
Ground floor moldings at floor surface	10%
Floors	20%
HVAC ductwork	20%
Exterior walls	10%
Interior walls	10%

Samples are collected by drilling through the entire building material with new 1/4-inch drill bits. A 3/8-inch carbide drill bit is used for concrete (with the objective of generating no more than a single sample volume). Drill cuttings and associated dust are vacuumed with a portable hand-held vacuum. At the completion of sample collection, the entire contents of the vacuum head, including the fiber portion of the vacuum filter, are packaged in a certified clean 8-ounce wide mouth glass jar and sealed for transport to the laboratory for analysis.

5.1.5 INDEPENDENT LABORATORY - LOUISVILLE, KENTUCKY

This laboratory samples whole-structure debris with LBP coatings and analyzes lead by the TCLP method for disposal determination. (Schmidt, 1993) Due to the fact that there are no current regulatory guidelines, they perform these jobs on a case-by-case basis using "good common sense" to get representative samples of the various building components.

One method is to separate the components by type and either analyze separately and adjust the results based on proportion by weight, or collect a weighted composite sample. If possible, a piece of debris is broken off to represent the entire thickness of a substrate, then it is crushed and collected as a sample. If it is not feasible to sample the entire thickness of a substrate, some known portion of the substrate is sampled and the resulting lead concentration is calculated over the entire substrate thickness. When using this approach, assumptions are made about the homogeneity of the lead distribution through the substrate, and about the depth to which the LBP has penetrated.

5.1.6 DEMOLITION/LEAD ABATEMENT CONTRACTOR - PEABODY, MASSACHUSETTS

This contractor uses a 3/8-inch punch to generate a 3/8-inch-diameter by 3/8-inch-length core. The sample is collected by punching through the entire substrate to obtain a sample representative of what is to be disposed. (Higgins, 1993) This 3/8-inch size was selected because it will fit through a 3/8-inch screen required by laboratories for TCLP method preparation. The contractor assumes that these plugs are not further processed (ground) by the laboratory and therefore the paint remains intact on the surface, unlike drilled cores or sawdust from cross-cutting methods.

This contractor has seen many TCLP (lead) threshold exceedences for abatement debris. In estimation, 90 percent of exterior components fail including, but not limited to, exterior siding, doors and window frames. (Higgins, 1992 and Higgins, 1993) The contractor believes that it is the sampling technique and not necessarily the selected sample location that affects the outcome of TCLP results for lead.

5.1.7 CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION

The Connecticut Department of Environmental Protection (CT DEP) is developing an approach that will rely primarily on portable X-ray fluorescence (XRF) readings to support sampling, segregation, and disposal decisions during whole-structure demolition. The approach under development currently includes the following steps:

1. Characterize painted surfaces using a portable deep penetrating XRF device and select the average, or perhaps the highest, XRF value.
2. Estimate the painted surface area.
3. Determine the product of the painted surface area (2) and the XRF concentration (1) to yield the mass of lead in the structure (safety factors may be recommended to provide conservative estimates of total lead mass due to potential error in surface area determinations and XRF readings).
4. Estimate the mass of the structure to be disposed using average densities and estimated volumes of building components (e.g., wood, concrete, brick, plaster).
5. Determine the estimated lead concentration in the structure using the estimated lead mass (3) divided by the estimated building mass (4).
6. Compare the estimated lead concentration in the structure (5) to a "recognized value" (e.g., 50 mg/kg total lead which represents a dilution factor of 10 compared to the TCLP method limit of 5 mg/L).
7. If the estimated lead concentration is higher than the "recognized value," then handle the building as a hazardous waste or perform more sampling, and possibly segregation, prior to demolition.
8. If the estimated lead concentration is lower than the "recognized value," then handle the building as a non-hazardous waste. (Binnell, 1993)

Information may be obtained by contacting the Waste Engineering and Enforcement Division of the CT DEP at (203) 566-4869

5.2 HYPOTHETICAL SAMPLING OPTIONS ANALYSIS FOR PERMEABLE DEBRIS

When evaluating the potential options for sampling permeable components of buildings and demolition debris containing LBP, the interests of the various parties that may be involved, including homeowners, demolition contractors, recyclers, landfill operators and federal, state, and local agencies, should be considered.

To protect human health and the environment, a conservative approach is used in making determinations about the hazardous/non-hazardous status of demolition debris and the regulatory threshold which determines its fate. However, rigorous procedural requirements and conservative regulatory thresholds can actually increase exposure problems by providing regulatory and economic impediments to demolition or abatement. Any procedure yielding results that frequently exceed the regulatory threshold will increase the amount of debris sent to Subtitle C facilities, decreasing the remaining capacity and increasing the cost of demolition. High demolition and disposal costs may result in buildings containing LBP being left undemolished. Instead of managing the LBP debris, the LBP coatings and surrounding contaminated soils would be left available to the public. (Spittler, 1992)

The best combination of environmental protection and cost-effectiveness is accomplished with approaches that segregate debris components and confirm hazardous determinations by TCLP analysis. This strategy tends to maximize the volume of non-hazardous material available for recycling and minimize the volume of hazardous waste. Screening tools such as X-ray fluorescence and chemical lead screening devices should be considered to support the segregation of components prior to each TCLP sampling event. See Section 5.3.1.3 for a discussion of these screening devices.

Sections 5.2.1 and 5.2.2 describe a matrix of hypothetical options for whole-structure sampling approaches (prior to or post-demolition) as outlined in Table 5-2. These options assume that all valuable and easily salvageable components, and all non-permeable (metallic) components have been removed from the structure prior to sampling, and that no other potential hazards, such as asbestos, exist. The hypothetical options are very general, but they present a variety of approaches to accomplish representative sampling.

TABLE 5-2

HYPOTHETICAL OPTIONS FOR SAMPLING PERMEABLE DEBRIS

HYPOTHETICAL OPTIONS FOR SAMPLING PERMEABLE DEBRIS <u>AFTER</u> DEMOLITION				
#	<u>Dismantle/Demolish</u>	<u>Segregate (Visual)</u>	Hazard Determination <u>(Analytical)</u>	Handling <u>Disposal/Recycle</u>
1.	• Dismantle all permeable components separately	• Pb-painted wood • Clean wood • Other	• Each homogeneous pile (N samples)	<u>Hazardous</u> • Handling • Transport • Records • TSD
2.	• Dismantle permeable LBP-covered components only: Demolish remainder of permeable components (no segregation)	• Pb-painted permeable debris • All other permeable materials	• Pb-piles (N samples) • Heterogeneous pile (1 sample)	<u>Non-Hazardous</u> • Handling • Land Disposal • Recycling • Burning
3.	• Demolish permeable components in entire structure (no segregation)	• All permeable materials (no segregation possible)	• Heterogeneous pile (1 sample)	

HYPOTHETICAL OPTIONS FOR SAMPLING PERMEABLE DEBRIS <u>BEFORE</u> DEMOLITION				
#	Hazard Determination <u>(Sampling)</u>	Hazard Determination <u>(Analytical)</u>	<u>Dismantle/Demolish</u>	Handling <u>Disposal/Recycle</u>
4.	• Each homogeneous permeable component in structure (whether or not it contains LBP)	• N samples of permeable components	• Dismantle Pb components in exceedence • Demolish remainder (no segregation)	<u>Hazardous</u> • Handling • Transport • Records • TSD
5.	• Pb-painted permeable components • Subsamples for all other permeable components	• Pb permeable component samples • Composite of all other permeable components (1 sample)	• Dismantle Pb components in exceedence • Demolish remainder (no segregation)	<u>Non-Hazardous</u> • Handling • Land Disposal • Recycling
6.	• Subsamples for all permeable components	• Composite of all permeable components (1 sample)	• Demolish entire structure (no segregation)	

These hypothetical approaches all require the sampler to make decisions regarding to representatively sample and create composite samples from one or more waste pile SW-846 Test Methods for Evaluating Solid Waste presents EPA's accepted approach to the challenge of sampling and compositing samples from waste piles. Inherent in this approach is some element of dilution due to the fact that wastes piles can never be totally homogeneous and that it is technically and economically infeasible to sample the entire waste pile. SW-846 accepts and recommends the analysis of composite samples and if necessary, reanalysis of recomposite samples to determine the variation of waste composition over time and space.

It is important to note that disposal requirements are often determined by local and state disposal regulations. Additionally, recycling options are usually determined by local markets (availability and profit margin). Sampling options and protocols should give results that are "meaningful" for making the determinations necessary to manage demolition debris in compliance with local applicable or relevant and appropriate requirements (ARARs). A brief discussion of each hypothetical option follows.

5.2.1 SAMPLING PERMEABLE DEBRIS AFTER DEMOLITION

The first three hypothetical options assume that the permeable components of the structure will be sampled after demolition with the clear advantage that the analytical data presented would represent the load that is to be managed.

5.2.1.1 Dismantle and Sample Each Building Component (Option 1)

This option assumes the owner/contractor will dismantle all building components separately. Each material would be segregated and placed in separate piles (e.g., painted wood, painted wallboard, clean wood). Each pile would be sampled and the sampled material prepared for analysis. A corresponding hazard determination would be made for each pile.

One pending question is, will disposal facilities require analytical data for all solid wastes to ensure that they are non-hazardous? For instance, will a municipal solid waste landfill operator require data for the unpainted (clean) wood? The answer may vary from state to state and could affect the extent to which dismantling and sampling of unpainted building components would actually be necessary.

5.2.1.2 Dismantle and Sample Each Lead Component/Demolish Other Components and Sample Composite (Option 2)

This option assumes the owner/contractor will dismantle all permeable building components coated with LBP prior to demolishing the remainder of the structure. Each building material coated with LBP would be segregated and placed in separate piles (e.g., painted wood, painted wallboard, painted wooden window frames, painted concrete). Each pile would be sampled and a hazard determination made for every type of painted waste.

Debris from demolition of the remainder of the structure (all unpainted surfaces) would be sampled (one composite per load made up of subsamples from each represented unpainted surface) only if the disposal, recycling, or burning facility requires data for all solid waste, including the waste determined to be non-hazardous by generator knowledge.

5.2.1.3 Demolish All Components and Sample Composite (Option 3)

This option assumes the owner/contractor will demolish the entire structure without dismantling or segregating any permeable building components. All non-permeable building components are assumed to be removed prior to sampling. In order to determine disposal requirements or recycling options, one composite sample would be taken per load of permeable debris. This option would only be recommended if careful screening procedures have been conducted and there is a high confidence level that potentially only a small fraction of the entire structure would be identified as a hazardous waste.

5.2.2 SAMPLING PERMEABLE DEBRIS BEFORE DEMOLITION

The final three hypothetical options assume that the permeable components of the structure will be sampled prior to demolition. Sampling a building prior to dismantling or demolition may give a better understanding of the applicable disposal options an owner/contractor will face before removing components or applying the wrecking ball. This approach may also eliminate the potential for contaminating an entire load with a potentially hazardous building component, by segregating the components likely to cause exceedence of the TCLP threshold for lead.

5.2.2.1 Sample Each Component (Option 4)

This option assumes the owner/contractor will take a composite sample of each homogeneous permeable building material within the structure. Those materials in exceedence of the regulatory threshold would be dismantled and managed as a hazardous waste. The remaining structure would be demolished and managed as a non-hazardous waste for recycling, bur ng, or disposal.

5.2.2.2 Sample Each Lead Component/Composite Other Components (Option 5)

This option assumes the owner/contractor will take a composite sample of each homogeneous permeable building material coated with paint. All other permeable materials would be quantified and a weighted composite sample taken. Those materials in exceedence of the regulatory threshold would be dismantled and managed as a hazardous waste. The remaining structure would be demolished and managed as a non-hazardous waste for recycling or disposal.

5.2.2.3 Composite All Components (Option 6)

This option assumes the owner/contractor will collect a weighted composi all permeable building materials within the structure. If the result is in exceedence of the regulatory threshold, the entire structure would be managed as a hazardous waste or a different sampling approach would be undertaken to segregate the building components causing the exceedence. If the results are below the regulatory threshold, the entire structure is managed as a non-hazardous waste for recycling, burning, or disposal.

5.2.3 RELATIVE COST AND CONFIDENCE LEVEL OF HYPOTHETICAL OPTIONS

Table 5-3 presents a comparison of the six hypothetical options, evaluating relative costs ranked by High, Medium, or Low for disposal/recycling, demolition/dismantling, sampling, and analysis. This is a relative ranking, and actual costs would be determined by a suite of other variables including but not limited to: salvage value of building components, local recycling markets, state disposal restrictions, structure size, percent of components within a structure coated with LBP, and the lead content of the paint (tc levels) c rious components within the structure. From high to low, these activities are a..icipated to ...ect demolition project costs in the following order:

- disposal/recycling (driving force)
- demolition/dismantling
- sampling
- analysis

Table 5-3 could be used as a tool for estimating the relative cost impacts to demolition projects based on job-specific information and local requirements.

TABLE 5-3
ANALYSIS OF HYPOTHETICAL OPTIONS

Options	Disposal/ Recycing Costs	Demolition/ Dismantling Costs	Sampling Costs	Analysis Costs	Confidence Level
SAMPLING AFTER DEMO 1	L	H	H	H	1
2	M or L	M	M	M	3
3	H or M	L	L	L	5
SAMPLING BEFORE DEMO 4	L	M	H	H	2
5	M or L	M	M	M	4
6	H or M	L	L	L	6

Notes:

Cost Impacts: L = Low M = Medium H = High

Confidence Level: Highest = 1 Lowest = 6

Cost impacts to projects from highest to lowest:

Rank
1. Disposal/Recycling costs (driving force)
2. Demolition/Dismantling costs
3. Sampling costs
4. Analytical costs

Confidence level, for the purposes of this table, means confidence in the representativeness of the hazard determination. Sampling each homogeneous building component after dismantling all components within the structure (Option 1) was ranked with the highest confidence level because each homogeneous building component would be tested to make a hazardous determination.

Option 4, sampling each homogeneous building component before demolition was also ranked highly with respect to confidence level. The selection of a sampling approach must balance confidence in the process with costs and other factors such as technical implementability and generator knowledge. These factors have been considered in the development of recommended sampling protocols, which are discussed in Section 5.3.

5.3 RECOMMENDED SAMPLE COLLECTION PROTOCOLS FOR PERMEABLE DEBRIS

Following an in-depth analysis of the existing protocols presented in Section 5.1 and the six hypothetical options described in Section 5.2, four recommended sample collection protocols were developed for permeable debris. These protocols discuss planning (Section 5.3.1), screening (Section 5.3.1.3), sampling (Section 5.3.2), and quality assurance/quality control (QA/QC) (Section 5.3.4).

The increase in solid waste quantities, the tightening land disposal requirements, and rising disposal costs all result in the need to segregate and treat hazardous debris and to find alternatives to land disposal (e.g., recycling, reuse, burning) for non-hazardous debris to the maximum extent possible. In recognition of these factors, demolition projects should be performed in two basic ways: (a) manual segregation, sample collection and hazard determination, demolition, and management; or (b) demolition, mechanical segregation, sample collection and hazard determination, and management.

There are two major goals that must be satisfied by any sample collection methodology. First, the sample(s) must be meaningful, representing the total volume being managed (e.g., are the DQOs specified for the demolition project met). Second, the samples should aid in the segregation of materials that are hazardous, therefore reducing treatment or special disposal requirements which are required for hazardous wastes. Based on current information from established sampling protocols, analysis of hypothetical sampling approaches, and knowledge of EPA sampling protocols for other types of media, this section offers a recommended approach for sample collection of permeable whole-structure demolition debris.

These sampling protocols a[illegible]ume that LBP is the only "hazard of concern" because all other potential hazards (e.g., asb[illegible]s, polychlorinated biphenyls) have been removed from the structure prior to sampling. It is assumed that non-permeable components of structure (e.g., I-beams, metal ductwork) will be segregated and recycled or reused for their salvage value and will not be sampled. Therefore, these protocols do not address sampling of non-permeable debris.

The selection of approach is site-specific and will depend on the following factors:

- size of structure
- contents of structure
- availability of mechanical processing facilities
- availability of recycle markets
- state/local landfill capacity and limitations
- economics of the above

While this protocol does not make site-specific decisions, it presents four sampling approaches that accommodate most situations. Three of the approaches describe sampling permeable debris components before demolition (Section 5.3.2.2) and the fourth describes sampling permeable debris after demolition (Section 5.3.2.4). Composite sampling is inherent in these approaches and is discussed in Sections 5.3.2.1 and 5.3.2.3. A brief summary of the four options is presented in Figure 5-1.

5.3.1 PLANNING

Planning a demolition project is an important first step in evaluating the level of effort required to manage the demolition wastes that will be generated. Building inspection and evaluation of building materials (surfaces) using screening tools is highly recommended to guide the owner/contractor in making accurate and cost-effective determinations for management of demolition wastes.

5.3.1.1 Research

Locate blueprints and building specifications to determine age, size, type of building materials (substrate) and building layout. Determine feasible options for recycling any materials within the structure. Become knowledgeable of local and state disposal requirements (e.g., what kind of manifests or data are needed to submit waste to a disposal, recycle, or burning facility).

FIGURE 5-1
SUMMARY OF RECOMMENDED SAMPLING APPROACHES FOR PERMEABLE DEMOLITION DEBRIS

Before Demolition - Case 1

Composite + | Composite –

- **Rationale** - Recommended when the high-risk (+) components are expected to be characteristically hazardous.
- **Benefit** - Expect to prove that Composite – is non-hazardous and keep Composite + segregated to reduce hazardous volume.
- **Risk** - None.

[illegible]emolition - Case 2

Composite – | Composite All

- **Rationale** - Recommended when the entire structure is not expected to be characteristically hazardous even though some components had high-risk screening results.
- **Benefit** - Expect to prove that Composite – is non-hazardous and hope to prove that Composite-All is non-hazardous.
- **Risk** - If Composite-All tests hazardous, reanalysis (per Case 1) is required to determine hazardous fraction.

Before Demolition - Case 3

Composite All

- **Rationale** - Recommended when screening indicated the absence of or low levels of lead on all components.
- **Benefit** - Single TCLP analysis.
- **Risk** - If entire building tests hazardous then resampling/analysis must occur.

Before Demolition - Case 4

Composite Pile

- **Rationale** - Recommended when the entire structure is not expected to be characteristically hazardous and few/no components had high-risk screening results. Also recommended when it is more feasible and/or cost-effective to process or segregate components following demolition.
- **Benefit** - Single TCLP analysis. Simplified sampling if performed on grid basis.
- **Risk** - If entire building tests hazardous and resampling does not change result, may be forced to segregate and resample or [illegible] entire structure as hazardous.

Key:

- **+** Composite of permeable components that indicate high presence of lead (high-risk components) based on screening prior to demolition
- **–** Composite of permeable components that indicate low/no presence of lead (low-risk components) based on screening prior to demolition
- **All** [illegible]osite of permeable components represented within the entire structure prior to demolition
- **Pile** Composite from pile of permeable components from demolished structure.

5.3.1.2 Building Inspection

Inspect the entire building from roof to basement or crawl space. Note valuable, recyclable, reusable and easily salvageable materials. Where feasible, remove components within the structure that have salvage value. Quantify the total square footage of each homogeneous permeable building surface within the structure and on the exterior. Carefully delineate between the surfaces that are coated with paint and the surfaces that are not (e.g., wallboard coated with paint and plain wallboard should be considered as two separate homogeneous materials). Since the fate of the building is dismantling or demolition, the inspection should be destructive to ensure an accurate calculation of all types of surfaces (e.g., peel off small areas of wall paper or wall paneling, remove a section of floor tiles to inspect the original floor) to find all paint-coated surfaces.

The building inspection will require careful documentation to aid in planning a sampling strategy to satisfy the ultimate disposal, recycling, or burning facility.

5.3.1.3 Use of Lead Screening Procedures During Building Inspection

It is highly recommended that lead screening procedures be used during the building inspection to identify the presence or absence of LBP surfaces. This information may be useful for determining whether additional composite samples should be taken and for grouping structural component types depending on the detection of lead. Screening results will give the demolition contractor an opportunity to segregate high-risk components (those components likely to have an influence on the outcome of TCLP). Separation of hazardous components may prove a cost-effective measure when disposal is required, unless the entire structure or mass of debris can be classified as clearly non-hazardous based on representative samples. (EPA, 1993a)

Two approaches to lead screening are currently being used: chemical tests kits and X-ray fluorescence (XRF) detectors. Chemical test kits are small, inexpensive devices that indicate the presence of lead by a color change when they have been applied to surfaces such as paints, metals, ceramics, dusts, and soil. Most test kits contain a chemical (either rhodizonate or sodium sulfide) that changes color in the presence of lead. This type of screening device is very simple to operate and inexpensive to use. The level of quantification is not reliable and does not predict lead leaching levels (as the TCLP method does); however, chemical test kits are potential lead screening tools for indicating the absence or presence of lead.

Note that federal agencies do <u>not</u> currently recommend using chemical test kit results as the basis for making decisions about abatement of lead in paint, soil, or dust. This recommendation should also be considered for demolition wastes Several chemical test kit evaluations are underway. After the evaluations are completed updated information will be available through the National Lead Information Center (National Lead Information Center, 1993) Also refer to the U.S. EPA Office of Pollution Prevention and Toxics study described in Section 11 3 2.

XRF detectors have a range of precision and depth of effective results. Some "shallow" surface probe XRFs evaluate only the top few layers of paint with high precision and accuracy, focusing on the amount of lead immediately accessible to affect human health. Unfortunately, these "shallow" XRFs will not necessarily detect LBP that is covered by multiple layers of non-leaded paint. Other "deep" surface probe XRFs detect the presence of lead through paint layers and into the substrate itself. This type of XRF tends to indicate false positives due to other lead sources such as wiring or metallic structural components. XRF detectors can be both portable and lab-based. While XRFs can provide quantification of total lead, those results do not correlate with TCLP values. XRFs also require both frequent calibration and user training, which has a greater impact on the use of portable detectors than the use of lab-based detectors. Despite these potential drawbacks, XRF is a viable lead screening tool.

Due to the limitations associated with lead screening devices, they are not recommended for use in identifying particular structural components as hazardous or non-hazardous wastes, nor for serving as the sole source of demolition debris management decisions; however, they can indicate the absence or presence of lead. These tools should only be used for preliminary screening to aid in sampling design.

5.3.1.4 Sampling and Analysis Plan/Quality Assurance Project Plan

In order to properly plan a sampling event, the sampling team should document in advance a plan for collecting samples representative of the waste stream. Types of information that should be included are the required quality assurance/quality control samples to be collected, and standard operating procedures for sampling and building demolition. Information and guidance for quality assurance procedures can be found in EPA SW-846, Test Methods for Evaluating Solid Waste, Volume IA, Chapter 1, and QAMS-005/80 - Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, 1983 (EPA-600/4-83-004). Note that these guidance documents are general in nature and that contractors must develop specific plans to address issues related to whole-structure building sampling events.

5.3.1.5 Job Hazard Analysis

Once the plan for sampling and demolition has been established, a job hazard analysis should be undertaken and a health and safety plan should be prepared. Appropriate methods for the protection of worker and public health and safety should be implemented. This protection may range from a simple requirement for the proper use of hard hats and safety glasses, to a more rigorous health and safety program requiring air sampling, respiratory protection, and containment with negative air as well as employee blood-lead level monitoring.

In light of recent Occupational Safety and Health Administration (OSHA) activities concerning occupational exposure to lead, and the application of the provisions of 29 C.F.R. Section 1910.1025 to the construction industry, which would include demolition activities, demolition contractors must place greater emphasis on programs designed to minimize and prevent occupational exposure to lead. Training programs, medical surveillance, respiratory protection, equipment and personnel decontamination, and exposure monitoring must be addressed during the performance of any work involving the disruption of surfaces which may result in the generation of airborne lead concentrations. The new regulatory requirements, which became effective on June 3, 1993, will require serious behavior modifications for contractors and contractor employees alike.

5.3.2 RECOMMENDED OPTIONS FOR SAMPLING APPROACHES

Four approaches are recommended for sampling permeable demolition debris. Three of the approaches assume the debris will be sampled prior to demolition and the fourth approach assumes the debris will be sampled following demolition. The selection of approach for a specific site may depend on the following factors: size of structure; contents of structure; availability of mechanical processing facilities; availability of recycle markets; state/local landfill capacity and limitations; and economic factors. Detailed discussions of the four approaches and the concept of composite sampling follow. Figure 5-1 summarizes the four recommended options. This section also presents a discussion on composite sampling, which is integral to the four recommended protocols.

5.3.2.1 Composite Sampling

Composite sampling is recommended for multi-component buildings requiring demolition. This recommendation is based on current sampling approaches and EPA-approved sampling methods. Compositing can be performed in different ways, and may be repeated or reconfigured in attempts to better represent the waste under evaluation. Therefore, the contractor should consider collecting excess sample volume for contingencies

"To ensure that recompositing can be done at a later date, it is essential to collect enough sample volume in the field so that, under normal circumstances, enough component sample will remain following compositing to allow for a different composite scheme or even for an analysis of the individual component type samples themselves. Then, if after reviewing the data, any questions arise, the samples can be recomposited in a different combination, or each component sample can be analyzed separately to determine better the variation of waste composition over time and space or to determine better the precision of an average number. The fact that this recompositing of samples can occur without the need to resample often results in a substantial cost savings." (SW-846 Test Methods for Evaluating Solid Waste, EPA, 1986c)

If the sampling event is well planned, and lead screening procedures are used, additional sample volume collection (insurance) may not be necessary. If there are some uncertainties about the sample composite scheme, collection of additional sample volume will require an initial additional labor expenditure to collect and reserve the extra sample volume; however, this approach may result in cost savings if samples require reanalysis and remobilization costs are avoided.

5.3.2.2 Before Demolition - Sample Collection from the Structure

All permeable building components should be sampled, with wood, brick, cement, siding, and plaster/wallboard being the most common components. Non-permeable building components such as glass, screen, aluminum siding, metal duct work, bulky process and utility equipment, steel tanks and I-beams should be segregated and managed separately as many of these materials tend to have high salvage values. These types of materials should not be included in a sampling scheme, because they are difficult to sample due to their high-density characteristics. Sampling these materials would not be cost-effective due to the labor and equipment intensity required to drill through the substrate. In addition, scrap metals are exempt from regulation as hazardous wastes if they are recycled. (40 C.F.R. Section 261.6(a)(3)(iii)).

To make an estimate of the "whole-structure" permeable waste stream prior to demolition, it is recommended that the owner/contractor, based on preliminary lead screening results or knowledge of the structure, select one of the three recommended compositing options (Table 5-4):

- Case 1 - A composite sample of all permeable high-risk components that indicate the presence of lead (composite +); and a composite of all permeable low-risk components that indicate the absence, or low levels of lead (composite -). This option is recommended when the owner/contractor suspects that the high-risk components will be characteristically hazardous due to toxicity.

- Case 2 - A composite sample of all permeable low-risk components that indicate the absence, or low levels of lead (composite -); and a composite of all permeable components within the entire structure (composite-all). This option is recommended when the owner/contractor suspects that the entire structure is not characteristically hazardous due to toxicity, but has detected lead in some high-risk screening results.

- Case 3 - A composite sample of all permeable components within the entire structure (composite-all) only. This option is recommended only if screening indicates the absence of, or low levels of lead on all components. The risk here, however, is that if the TCLP result exceeds the regulatory threshold, the owner/contractor would be unable to identify and segregate the components causing exceedence based on analytical results. Therefore, the structure would have to be reanalyzed, or managed entirely as a hazardous waste.

TABLE 5-4
SAMPLE COLLECTION FROM THE STRUCTURE OPTIONS FOR COMPOSITING

Component Category	Case 1	Case 2	Case 3
Composite +	Composite +	------	------
Composite -	Composite -	Composite -	------
Composite All	------	Composite All	Composite All

Notes:
+ : Permeable components that indicate presence of lead (high-risk components) based on screening
- : Permeable components that indicate absence of, or low levels of lead (low-risk components) based on screening
All : Permeable components represented within the entire structure.

The total area from which one single composite sample is collected should be limited to 2,500 square feet. Larger areas will require the collection of an additional composite. For instance, if the area of building components requiring management is 4,000 square feet, it is recommended that two composite samples be collected representing 2,000 square feet each.

The proportional surface area of each homogeneous building material to be composited should be determined based on estimated square footage. The total estimated areas of each homogeneous building material should be compared to one another to establish ratios. The ratios will determine the weight or volume of subsample material required from each homogeneous building material to make up the appropriate percentages within the composite samples collected.

For each composite sample that represents a different subset of permeable building components, a calculation of the proportional surface area for each individual subset is required. Sufficient subsample material should be collected from randomly selected locations of each homogeneous building material to ensure enough volume for the composite sample(s) and any QA/QC samples required.

5.3.2.3 Evaluation of Composite Sample Results

Table 5-5 presents a matrix of the possible TCLP outcomes for different compositing strategies, and the recommended corresponding action items. In recognition of the national solid waste dilemma, and EPA's strategy of minimizing landfilling, it is important to segregate hazardous wastes from non-hazardous wastes to the maximum degree possible. Devising a compositing strategy that uses screening tools to aid in component categorization is an attempt to segregate the hazardous wastes. Screening results from components that indicate no/low lead content on the surface, yet are determined to be hazardous by TCLP, would be an unexpected outcome. Decisions for resampling and/or management of these components would be required.

5.3.2.4 After Demolition - Sample Collection from the Debris Pile

As an alternative to segregating the structure prior to sampling, the structure can be demolished first and the resulting debris pile can be sampled, tested and managed as a single waste. The debris pile can also undergo a combination of manual and mechanical processing (e.g., sorting, chipping, grinding, flotation) to create segregated waste piles prior to sampling and management. This approach is recommended when the entire structure is not expected to be characteristically hazardous and few or no components had high-risk screening results. This approach is also recommended for cases where it is more feasible or cost-effective to process or segregate components following demolition.

This sampling approach is applicable to permeable debris only. Non-permable building components such as glass, screen, aluminum siding, metal duct work, bulky process and utility equipment, steel tanks and I-beams should be segregated and managed separately, as many of these materials have high salvage values.

The following approach for sampling waste piles was extracted from SW-846, Test Methods for Evaluating Solid Waste, Vol. II, Ch. 9, p. 77: "In waste piles, the accessibility of waste for sampling is usually a function of pile size, a key factor in the design of a sampling strategy for a wastepile. Ideally, piles containing unknown wastes should be sampled using a three-dimensional simple random sampling strategy. This strategy can be employed only if all points within the pile can be accessed. In such cases, the pile should be divided into a three-dimensional grid system, the grid sections assigned numbers, and the sampling points then chosen using random-number tables or random-number generators. If sampling is limited to certain portions of the pile, then the collected sample will be representative only of those portions, unless the waste is known to be homogeneous." (EPA, 1986c)

TABLE 5-5
EVALUATION OF COMPOSITE RESULTS

	TCLP OUTCOME			
Case 1				
Composite +	Hazardous	Hazardous	Non-hazardous	Non-hazardous
Composite -	Non-hazardous	Hazardous	Non-hazardous	Hazardous
Action Item	Expected result. Screening results were validated. Treat low-risk components as non-hazardous. Treat high risk components as hazardous.	Unexpected result. Screening results were not validated for low-risk components. Reanalyze low-risk composite and/or individual low-risk components, or treat whole structure as hazardous.	Screening results for high-risk components indicated total lead, not leachable lead. Treat whole structure as non-hazardous.	Unexpected results, inconsistent with screening. Reanalyze low-risk composite and/or individual low-risk components.
Case 2				
Composite All	Hazardous	Hazardous	Non-hazardous	Non-hazardous
Composite -	Non-hazardous	Hazardous	Non-hazardous	Hazardous
Action Item	Unexpected result for composite of all components. Screening results for low-risk components were validated. Low-risk components are non-hazardous. Reanalyze high-risk composite or individual high-risk components as in Case 1.	Unexpected results for low-risk and all components. Reanalyze individual components, or treat whole structure as hazardous.	Expected result. Treat whole structure as non-hazardous.	Unexpected results for low-risk components, inconsistent with screening. Recomposite, or reanalyze individual components.

TABLE 5-5
(Continued)

Case 3				
Composite All	Hazardous	Hazardous	Non-hazardous	Non-hazardous
Action Items	Unexpected results, if screening indicated low risk. Recomposite, or reanalyze individual components, or treat whole structure as hazardous.	Unexpected results, if screening indicated low risk. Recomposite, or reanalyze individual components, or treat whole structure as hazardous.	Expected result. Screening results were validated. Treat whole structure as non-hazardous.	Expected result. Screening results were validated. Treat whole structure as non-hazardous.

Notes:

Composite All : composite sample of all permeable components
Composite + : composite sample of permeable high risk components (based on screening)
Composite - : composite sample of permeable low risk components (based on screening)

Hazardous : > 5.0 mg/l for lead
Non-hazardous : < 5.0 mg/l or lead

"In cases where the size of a pile impedes access to the waste, a set of samples that are representative of the entire pile can be obtained with a minimum amount of effort by scheduling sampling to coincide with pile removal. For the number of truckloads needed to remove the pile should be estimated and the truckloads randomly chosen for sampling." (EPA, 1986c)

To make a hazard determination of the debris pile, it is recommended that one composite sample be analyzed for the load. Defining load in terms of maximum weight or volume varies among other established protocols. For example, the DHA uses 6,000 kilograms as a maximum weight per load of abatement waste. EPA Region VII recommends one composite sample per 500 cubic yards or less of demolition debris (made up of no more than 50 aliquots). It is recommended that a limit of 500 cubic yards or less be placed on the size of the pile represented by one composite sample.

One potential disadvantage to the "pile" approach is that, depending on the result of the hazard determination, the entire debris pile (or truck load) may be subject to management as a hazardous waste. An alternative to debris sampling being used in some areas of the country, including New

England, is the use of a debris processing facility to further segregate the debris. Specialized equipment, including grinders, screening devices, and flotation devices, are required to sort and segregate debris. These types of equipment are usually located at a fixed processing facility, although mobile equipment is also available. Testing of each debris component should be performed, if required, prior to further management (e.g., recycling, burning, disposal). State permitting requirements for such facilities vary (see Table 3-1).

5.3.3 SAMPLE COLLECTION METHOD

Prior to collecting samples from each of the homogeneous permeable building materials, it is recommended that the volume of an aliquot from each type of substrate be calculated (e.g., 1/4-inch diameter drill bit multiplied by 4-inch substrate) to determine how many aliquots of each material will be required to make up a 110.0-gram sample for TCLP analysis (in addition to material representation requirements). It is recommended that excess sample be collected to allow for reanalysis.

Samples should be collected using a 1/4-inch to 1-inch drill bit by drilling through the entire substrate. A 3/8-inch carbide drill bit should be used for concrete. Drill cuttings and associated dust should be collected by allowing them to fall into a disposable sample container such as an aluminum pan. The remaining sample dust and cuttings should be vacuumed using a hand-held vacuum to ensure collection of the entire substrate thickness. Sufficient substrate material from each homogeneous area should be collected to contribute the appropriate volume to the composite sample.

The vacuum cleaner fiber filter should be dedicated to each homogeneous subsample group (homogeneous building material) to minimize cross contamination. Non-dedicated sampling equipment, such as drill bits and the head of the hand-held vacuum, should be decontaminated between sampling of each homogeneous subsample group. Sampling personnel should decontaminate equipment by first brushing the excess material from the equipment and then washing using tap water and soap. This should be followed by a final rinse with distilled water.

Once the appropriate volume of each homogeneous building material has been collected, the material should be transferred to a certified-clean wide-mouthed glass jar that holds 8 ounces or more to accommodate sufficient mass for duplicate analyses.

5.3.4 QUALITY ASSURANCE/QUALITY CONTROL SAMPLES (QA/QC)

The QA/QC data obtained from field duplicates, rinsate blanks and matrix spike/matrix spike duplicates (MS/MSDs) should be reviewed to ensure that the precision and accuracy of the analytical results meets or exceeds the DQOs for the sampling event. QA/QC data should be reviewed by a chemist to determine data quality and to identify specific problems that may interfere with data usability.

EPA QA/QC sample requirements can vary from region to region. In general, there are two kinds of QA/QC samples, field and analytical. Field duplicates and rinsate blanks are considered field QA/QC because they provide a check on field sampling techniques and decontamination procedures, respectively. MS/MSDs would be considered analytical QA/QC because they allow the laboratory to check the precision of analytical equipment and analytical processes. General information and guidance for QA/QC sampling and analytical procedures are found in EPA SW-846, Test Methods for Evaluating Solid Waste, Volume IA, Chapter 1. (EPA, 1986c) A recommended QA/QC sample schedule is as follows:

- Field Duplicate: 10% (minimum of 1)/sample event.
- Rinsate Blank (if equipment decontamination is required): 1/sample event.
- MS/MSD: 5% (minimum of 1)/laboratory batch/sample event.

A field duplicate should be taken to check the quality and consistency of collecting and transferring the subsample material to a sample container. These steps should be duplicated using the same field sample collection technique to produce a field duplicate. It is recommended that drill holes be made adjacent to one another and the frequency of collection for each substrate be identical for field duplicate preparation. A rinsate blank is collected by pouring analyte-free water over equipment that has been decontaminated between sample points (homogeneous substrates) to check the thoroughness of decontamination procedures. Note that it may be more cost-effective to use dedicated sampling tools (e.g., drill bits) for each homogeneous substrate. This method would minimize cross-contamination and would eliminate the need for a rinsate blank, thus reducing the cost of analysis. The required volume for a MS/MSD sample is usually laboratory- and method-specific. The MS/MSD is prepared by the laboratory using the TCLP extract as part of the laboratory's quality control program. The laboratory would need to be contacted to determine if additional sample volume would be required.

5.3.5 SUMMARY OF RECOMMENDED SAMPLE COLLECTION PROTOCOLS

The recommended sample collection protocols consist of the following components.

1. Plan the sampling in detail including:

   - Research the structure
   - Inspect the structure
   - Perform lead screening on all structure components
   - Develop Sampling and Analysis Plan/ Quality Assurance Project Plan
   - Perform Job Hazard Analysis and Develop Health and Safety Plan

2. Remove non-permeable components from the structure for recycle, reuse or other salvage purposes.

3. Select a sampling approach for permeable components based upon screening results. Determine subsamples to be composited and timing of sampling (before or after demolition). Recommendations include:

   - Before Demolition
     Case 1 - analysis of composite of all permeable high-risk components that indicate the presence of lead <u>and</u> analysis of a composite of all permeable low-risk components that indicate the absence or low levels of lead. Case 1 is recommended when the high-risk components are suspected to be hazardous.

     Case 2 - analysis of a composite of all permeable low-risk components that indicate the absence or low levels of lead <u>and</u> an analysis of a composite of all permeable components. Case 2 is recommended when the presence of lead has been detected in some components, but the entire structure is suspected to be non-hazardous.

     Case 3 - analysis of a composite of all permeable components. Case 3 is recommended if all screening results indicated the absence or low levels of lead.

   - After Demolition - analysis of one or more composites of the permeable debris pile, collected randomly.

4. Perform sampling including QA/QC samples. Use 1/4-inch to 1-inch drill bits. Drill through the entire substrate or pile and collect the drill cuttings and associated dust.

5. Evaluate sampling results to make a hazardous determination for each set of building components represented by a composite sample.

6. If sample results are unexpected (e.g., composite of permeable low-risk components exceeded 5.0 mg/L in TCLP), use the rationale in Table 5-4 to determine whether additional sampling and analysis is warranted.

6.0 SAMPLE ANALYSIS

Laboratory analysis of construction and demolition (C/D) debris samples presumed to contain lead-based paint (LBP) is required to determine whether or not the waste debris is hazardous. According to 40 C.F.R. Part 261, determination of the hazardous characteristic of toxicity requires analysis of the waste by a method known as the Toxicity Characteristic Leaching Procedure (TCLP).

6.1 TOXICITY CHARACTERISTIC LEACHING PROCEDURE

The TCLP method is designed to determine the mobility of both organic and inorganic analytes present in liquid, solid and multiphasic wastes. It is intended to simulate the conditions in a landfill environment, and is defined in 40 C.F.R. Part 261, Appendix II, Method 1311.

The TCLP method requires that the sample be reduced in particle size so that all particles fit through a 9.5-mm (0.375-inch) screen. The TCLP method also requires a subsample to be reduced to approximately 1 mm or less in particle size for the determination of the appropriate extraction fluid (I and II). This reduction in particle size may be accomplished by either cutting, crushing, or grinding.

Because the particles must fit through the screen, an issue currently unresolved in the waste management community is whether to send the laboratory (1) a sample of powdered material having the smallest particle size obtainable, (2) a sample of particles as large as possible that still fit through the sieve, or (3) large chunks of material that the laboratory will reduce in size. At issue is whether or not surface area is a factor in determining TCLP lead concentrations. (Nadler, 1992) Substantial data was not found to verify this possibility; however, conflicting sample collection methodologies are currently practiced as discussed in Section 5.0.

Recognizing that the screen size used with the TCLP method is 3/8 inch (0.375 inch), and believing that collecting as large a sample as is allowable will yield the lowest possible TCLP lead result, a demolition/lead abatement contractor from Massachusetts collects samples using a 3/8-inch-diameter core. (Higgins, 1993) However, this contractor cannot substantiate whether or not this has systematically reduced the TCLP results. The Denver Housing Authority (DHA) takes the opposite approach based on apparent field experience. The DHA used to send solid pieces of wood for TCLP analysis but now sends sawdust samples, and indicates that the sawdust samples are yielding lead results lower than the results for larger wood chunks. (Ward, 1993) Preliminary discussions with laboratory personnel indicate that the lower results obtained from the sawdust samples may be a result of the fine wood particles essentially dissolving into the extractant solution along with the lead. Detailed study of this phenomenon will be necessary to substantiate or refute this suggestion.

The U.S. Environmental Protection Agency (EPA) Office of Research and Development, Environmental Monitoring Systems Laboratory suggested that leaching large chunks of debris, rather than grinding the sample, would be more representative of actual landfill conditions; however, this process would be in conflict with TCLP methodology. (Rupp, 1992) Others agree with this position, and suggest that the sample should reflect disposal conditions. The contention is, if the material to be landfilled is predominantly fines, then fines should be collected and sampled, and if the material to be landfilled is predominantly chunks, then chunks should be collected and sampled. (Sandberg, 1993)

EPA continues to evaluate levels of lead and other metals as determined by TCLP analysis. EPA is also evaluating new dilution attenuation data, which may have an effect on future TCLP action levels. (Topping, 1992)

6.2 SYNTHETIC PRECIPITATION LEACHING PROCEDURE

The use of the TCLP method as an indicator of the potential for lead to leach from landfills is considered by some regulatory personnel to be "technically unsound" because this artificial mobilization is effected by the organic extractant: acetic acid. Acetic acid solubilizes lead as lead acetate, which is the only soluble form of lead, when normally only dilute mineral (inorganic) acids exist in landfills. (Spittler, 1992) For this reason and others, EPA is testing a new leaching procedure, the Synthetic Precipitation Leaching Procedure (SPLP), Method 1312, also known as the acid rain test. The major difference between the two methods is that the TCLP method uses an organic acid (acetic), while the SPLP method uses an inorganic acid which is similar to the acids in natural precipitation (rain, snow and fog).

In an EPA background comparison study of lead levels from the U.S. Department of Housing and Urban Development (HUD), lead abatement wastes were an order of magnitude less when analyzed with the SPLP method than with the TCLP method. This study, extracted in Table 6-1, found that for the nine samples analyzed by both methods, TCLP results were greater than SPLP results by a range of 2 to 35 times (Topping, 1993) Total lead measurements are also provided for comparison purposes.

TABLE 6-1

DATA COMPARING SPLP AND TCLP METHODS

Sample #	SPLP Method 1312 (mg/L)	TCLP Method 1311 (mg/L)	Total Analysis Method 6010 (mg/kg)
1	0.114	0.803	1090
2	0.152	2.55	1260
3	0.0328	0.501	71.7
4	2.00	11.3	3310
5	0.010 U	0 010 U	17 3
6	0.165	2.36	132
7	0.131	0.258	393
8	0.085	2.15	78.9
9	0.132	4.73	995

Source: (Topping, 1993)

These limited data indicate that lead leachability is strongly dependent on the leaching acid, and it raises the question of what is the best method to determine whether a waste is characteristically hazardous by toxicity. Further study is required on this issue, because potentially substantially reduced quantities of C/D debris would be determined to be hazardous if the TCLP method were replaced by the SPLP method, without changing the action levels.

The State of New York is currently directing contractors to perform SPLP analysis for soil leachate analysis when the soil will remain on the facility property. In contrast, soil that will be excavated and relocated off the facility property will be subject to TCLP analysis. This compound approach could be confusing and may require increased analytical costs. The TCLP standard is evidently thought to be too low by some, including the State of New York. If appropriate, the TCLP action levels should be raised, or the TCLP should be replaced, but it is not recommended to implement multiple analysis methods for different circumstances.

6.3 SCREENING TOOLS

Screening tools may be employed to estimate which materials are more likely than others to test as hazardous. Screening tools may not be used in place of TCLP analysis, nor will they accurately predict the TCLP results. The primary function of screening tools is to distinguish the materials likely to contain LBP, from those that likely do not. This screening can then be used to assist in the segregation of materials, effecting hazardous waste minimization. Currently two screening tools are available: X-ray fluorescence (XRF) detectors and chemical test kits.

An XRF detector is commonly used in environmental investigations, such as LBP investigations, to screen for the presence or absence of metals in the media being measured.

XRF detectors can be used both in the field and in the laboratory In the case of LBP investigations, the XRF instrument irradiates the paint on the surface, causing lead in the paint, if present, to fluoresce, emitting a characteristic frequency of radiation, the intensity of which is measured by the detector and related to the amount of lead in the paint. XRF has been used in the past as a screening tool to indicate the presence or absence of lead in paint. (Drosdz, 1992) Other studies, which have attempted to correlate XRF measurements with TCLP measurements, have not been successful in establishing an accepted correlation. (Cox, 1992)

Data from one XRF/TCLP study prepared for EPA's Office of Solid Waste in 1990 are shown in Table 6-2. The data are arranged in order of decreasing TCLP extract concentration. The report suggests that debris was generally found to be hazardous only if the lead level in the paint, as measured in the laboratory by Atomic Absorption Spectrometry (AAS), exceeded approximately 4.0 mg/cm². The usefulness of the AAS data here is to demonstrate the degree of confidence in field XRF measurements, which varies between studies, and is rather low in this study. Total lead levels are also provided for comparison purposes. In this study, measurements of the paint

TABLE 6-2

COMPARISON OF FIELD AND LABORATORY LEAD DATA

Sample #	Field Measurement XRF (mg/cm^2)	Laboratory Measurements AAS (mg/cm^2)	TCLP (mg/L)	Total (mg/kg)
1	3.4 - 5.1	5.9	21	94800
2	9.3	6.1	13	103000
3	5.3	9.7	12	50400
4	19.4	9.4	10	171000
5	19.4	9.4	9 5	174000
6	3.9	2.8	5.4	24300
7	6.2	8	4 8	96500
8	0.86	6.8	4.5	32700
9	0.72	5.3	4.1	5360
10	0.028	8.2	3.4	580
11	2.8	4.6	2.5	40400
12	3.9	4.8	2.3	43800
13	0.38	N/A	2.1	21700
14	3.4	8.7	1.2	98200
15	2.9	4.8	1.0	27400
16	0.54	3.1	0.9	6240
17	2.2	3.7	0.8	20400
18	1.1	3.1	0.4	15300
19	0.016	3.1	<0.3	670
20	0.12	N/A	<0.3	2430

Notes: XRF: X-ray fluorescence. AAS atomic absorption spectrometry
Source: (Cox, 1992)

lead levels by field XRF were poorly correlated with TCLP results. The data show that XRF is not a good indicator of TCLP or total lead levels, and that XRF results tend to be greater than TCLP results when each is compared to the relevant threshold level, erring in favor of increased hazardous waste determinations. (Cox, 1992)

In addition to the study mentioned above, a separate study completed by the U.S. Army at Fort Devens attempted to correlate XRF with TCLP data. In this study, the Army also found no correlation between XRF measurements in the field with TCLP results in the laboratory. (Josephson, 1992)

The Louisville Housing Authority (LHA) also attempted to develop guidelines relating TCLP and XRF measurements. They hypothesized that in order to get a TCLP reading above the toxicity limit, the XRF reading must be "high" and the substrate must be "thin" or "not dense." LHA also concluded that surface lead (XRF) and total lead results do not correlate. (Adams, 1992)

The Denver Housing Authority has hundreds of data points currently being entered into an electronic data base. One goal of DHA is to attempt to develop a correlation between XRF and TCLP data from abatement projects. (Ward, 1993) However, these data are not available for review at this time.

While XRF may be able to confirm the presence of LBP, it cannot be used to determine whether the LBP will fail the TCLP analysis. Therefore, it is recommended that the use of XRF as a screening device be limited to determining the presence or absence of LBP. XRF instrument criteria should be determined prior to selecting a specific detector, because various models of XRF instrumentation have different sensitivities to LBP.

Chemical test kits are small, inexpensive devices that indicate the presence of lead by a color change when they have been applied to surfaces such as paints, metals, ceramics, dusts, and soil. Most test kits contain a chemical (either rhodizonate or sodium sulfide) that changes color in the presence of lead. This type of screening device is very simple to operate and inexpensive to use. The level of quantification is not reliable and does not predict lead leaching levels (as the TCLP method does); however, these test kits are potential lead screening tools for indicating the absence or presence of lead.

Note that federal agencies do <u>not</u> curently recommend using chemical test kit results as the basis for making decisions about abatement of lead in paint, soil, or dust. This recommendation should also be considered for demolition wastes. Several chemical test kit evaluations are underway. After the evaluations are completed, updated infromation will be available through the National Lead Information Center. (National Lead Information Center, 1993)

The EPA Office of Pollution Prevention and Toxics (OPPT) is conducting one such study comparing results from various technologies for field measurement of lead in LBP. (Schwemberger, 1993) The results of the study will be considered by HUD in the development of guidelines for abatement of federally assisted housing. The ongoing OPPT study evaluates the variability in common LBP field measurement techniques, including six lead test kits and nine portable XRF instruments. Painted surfaces in houses in Denver and Philadelphia are being tested using both types of field measurement devices. Confirmation samples are being analyzed at fixed-based laboratories using standard analytical instruments. The following painted surfaces are being analyzed in each house: metal, wood, concrete, brick, drywall, and plaster. The study is ongoing at this time.

6.4 RECOMMENDED SAMPLE ANALYSIS PROTOCOL

Currently, the federal Resource Conservation and Recovery Act (RCRA) requires analysis of hazardous waste toxicity using the TCLP method. This method should be used for analysis of LBP.

Available data suggest that neither XRF nor chemical test kits should be used to determine whether a sample will pass or fail the TCLP test. These screening tools are only potentially useful for determining the absence or presence of total lead. Where lead is positively identified using XRF or a chemical test kit, a sample should be collected for laboratory analysis by TCLP. Note that federal agencies do not currently recommend using chemical test kits as the basis for making decisions about abatement of lead in paint, soil, or dust. This recommendation should also be considered for demolition wastes.

7.0 MANAGEMENT OF NON-HAZARDOUS C D DEBRIS

Several legitimate management options currently exist for components of construction and demolition (C/D) debris that have been determined to be non-hazardous. The options include:

- landfilling in a Subtitle D, municipal solid waste (MSW), or C/D landfill
- combustion in energy recovery facilities
- recycling various C/D debris components into other products, such as fill material, road base or landscape mulch

The selection of a specific management option is typically an economic decision made by the demolition contractor based upon factors such as debris quantity and composition; and the availability, location, regulatory requirements, and cost associated with the management option. Landfilling is currently the most commonly selected approach. However, due to decreasing landfill capacity, sharply increasing costs, and changing regulatory requirements, the viability of landfilling for C/D debris is rapidly decreasing. The combustion of wood debris is gaining in popularity because it generates revenue for the demolition contractor through the sale of waste wood to combustion and waste-to-energy facilities. Burning debris is an alternative to burning more expensive fossil fuels and virgin wood. Concerns about emissions and uncertainties about C/D wood debris generation rates have impeded growth for this management option. The recycling of various C/D debris components is also occurring on a small scale, but this approach offers a large expansion potential if stable markets can be established for the recycled products.

Unfortunately, a growing percentage of C/D debris is not managed using these three options. Some Northeast Waste Management Officials' Association (NEWMOA) states have reported incidents of illegal disposals creating potential human health and environmental risks. (Lambert, 1992) The development and use of a protocol for non-hazardous C/D debris may reverse that trend.

Discussions of three legitimate management options and related benefits and drawbacks follow. A recommended protocol for managing and handling these non-hazardous wastes is also presented.

7.1 LANDFILLING

Landfilling of non-hazardous C/D debris in MSW or C/D landfills, a once common practice, is facing significant environmental, economic, and capacity problems. A major environmental concern is leachate generation. Major waste hauling/disposal firms have published reports on environmental releases from C/D landfills concluding that liners, leachate collection systems and similar controls are warranted. (Brickner, 1992) Some states have banned the disposal of C/D in MSW landfills due to this leachate concern. Other states have promulgated strict C/D landfill regulations, similar to those for MSW landfills. Liners and leachate collection systems are now required for C/D landfills in the states of Massachusetts, New Hampshire, and New Jersey. In Connecticut and Massachusetts, C/D landfills must meet groundwater testing and surface water monitoring requirements. (Lambert, 1992)

Table 7-1 presents the results of a survey of state solid waste regulatory agencies conducted in the Spring of 1992 focusing on regulatory requirements for MSW and C/D landfills. The majority of the states have less stringent requirements for C/D landfills than MSW landfills: approximately 84 percent of the states do not require C/D landfills to meet MSW landfill regulations, 86 percent of the states have separate regulations for C/D landfills, and landfill exclusions are granted to C/D wastes in 64 percent of the states.

TABLE 7-1

NATIONAL C/D WASTE REGULATORY OVERVIEW

No. of permitted MSW landfills	5,654
No. of C/D waste landfills	1,807
No. of C/D waste recycling/processing facilities	113

STATE C/D WASTE LANDFILL REGULATIONS

	YES	NO	NR
• Must meet MSW landfill regulations	8	42	0
• Have separate regulations	43	5	2
• Have C/D waste landfill exclusion	32	14	4
• States that require permits for C/D processing facilities	30	15	5

Source: Data independently compiled through contacts with state solid waste regulatory agencies by Gershman, Brickner & Bratton, Inc. (GBB), 1992

Landfill tipping fees have risen substantially in response to the increasing landfill construction and operation requirements and decreasing available capacity. Fees of $50 to $60 per ton are commonplace in states such as Florida, where the high groundwater table severely restricts landfill siting. (*Demolition Age*, 1992) Some New Jersey counties are paying tipping fees of $130 per ton to transport and dispose C/D debris to in-state or out-of-state landfills. (Lambert, 1992)

Landfill capacity is rapidly shrinking for all wastes, and bulky C/D debris typically fills more volume per mass than municipal solid wastes. Therefore the banning or limiting of C/D wastes in landfills is a growing trend. Approximately 5,600 MSW and 1,800 C/D waste landfills currently exist in this country. (Brickner, 1992) These numbers are not likely to grow at a rapid pace. Stricter requirements for new landfills defined by the October 9, 1993 effective date for Solid Waste Disposal Facility Criteria (40 C.F.R. Parts 257 and 258) will restrict the siting of new MSW landfills. This federal requirement will affect all states because the federal Resource Conservation and Recovery Act (RCRA) required that by April 9, 1993 states must have adopted and implemented a permit program to ensure that MSW landfills are in compliance with Part 258. C/D wastes are not defined in the federal regulation but are expected to be addressed by each state.

The future of landfilling as a management option for non-hazardous C/D debris is very limited due to significant environmental, economic, and capacity problems. Although landfilling is currently the first choice of most demolition contractors, it is the last choice in the U.S. Environmental Protection Agency's (EPA's) integrated solid waste management strategy, and other alternatives such as burning and recycling are more viable for managing non-hazardous C/D lead-based paint (LBP) debris.

7.2 BURNING

The use of waste wood for fuel provides potential opportunities for increasing renewable energy use, alleviating the solid waste disposal problem, and reducing fuel costs. Several facilities in the U.S. currently combust waste wood as all or part of their fuel stream, and interest from other power producers and industries is growing quickly. Conversely, there are major technical and environmental issues that require more study to determine the effects of burning treated wood either exclusively or with other wastes. The lead released through air pollution control devices in the ash is a significant concern and requires more research and evaluation. In addition to the technological questions, public perception is another important factor to consider with respect to this emerging technology. Many developers attempting to permit recycled wood combustion facilities are receiving strong public opposition.

Conceptually, the process of segregating and chipping non-hazardous wood debris and burning it to produce process steam and electricity is a viable management alternative with dependable product markets. Whether burning should be defined as "recycling" elicits different opinions. Some states such as New Jersey do not consider this approach to be true recycling, limiting the economic incentives associated with it. In contrast, the EPA-funded Recycling Advisory Committee of the National Recycling Coalition considers wood chip combustion for energy production a vital reuse of a waste product. (Brickner, 1992)

Regardless of the definition, there are many advantages to burning non-hazardous wood debris including the following:

- reduces reliance on fossil fuels
- increases use of waste products
- reduces utilization of landfill capacity
- reduces reliance on virgin wood
- reduces sulfur dioxide emissions of coal during during cofiring
- lowers energy costs, compared to fossil fuels
- provides a plentiful energy source

The majority of the C/D wood that is currently burned in power plants or energy recovery facilities is untreated or clean wood. The combustion of untreated non-hazardous wood does not present significant environmental concerns. However, the combustion of non-hazardous C/D debris that contains wood that has been treated or coated with paint, varnish, stain, preservatives, plaster and laminating agents has the potential to release contaminants through both air emissions and the ash. The sources of contaminants are the constituents (i.e., metals) used in the manufacturing of the paint.

Paint typically comprises less than 0.1 percent by weight of a painted piece of wood, and only a fraction of that percentage is made up of metals. (Grasso, 1990) Some power plants are requiring "certification" from demolition contractors that the lead content in non-hazardous wood debris is below specific levels or is not present at all, prior to accepting this waste. (Taylor, 1992) Details concerning the information required in the certification were not available.

An efficient particulate control system at a wood-fired facility could reduce metal emissions from painted wood combustion to levels below regulatory limits. (Grasso, 1990) Further study is recommended on a range of treated wood samples to verify the effectiveness of the combustion process and particulate control system.

Wood processing units such as hoggers and chippers may remove much of the paint or other coating, depending on the level of absorption into the wood surface. (Fehrs, 1992) However, this removal will largely be a function of the mechanical design of the processing equipment. Unless the screen size is relatively small and the wood passes through the grinding mechanism multiple times, the paint may remain on the surface. Additional study is warranted to determine the effectiveness of these processing units, and to evaluate whether they further reduce contaminant levels in wood feed stocks, thereby decreasing lead levels in air emissions and ash.

Regulatory issues are particularly complex with respect to combustion of wood debris. Concerns include the following:

- Non-attainment provisions and New Source Performance Standards resulting from the Clean Air Act Amendments will affect siting and permitting of new waste wood combustion facilities. (NYSERDA, 1991)
- The "incineration" status of waste wood boilers (in New York and other states) could be an impediment to the development of wood energy. (NYSERDA, 1991)
- Characterization and classification of specific waste wood types for use as fuel are required. (NYSERDA, 1991)
- Options for ash uses such as compost and soil amendment products require evaluation. (NYSERDA, 1991)

Despite the regulatory and technical issues to be resolved, there is a growing acceptance among state energy planners that waste wood fuel can be an important component of an overall renewable energy supply strategy. Table 7-2 presents a sampling of eight states that have developed wood energy policies.

Cement kilns also offer potential options for burning C/D wood debris, both non-hazardous and hazardous. Refer to Section 8.3 for a discussion of this approach, which is in sporadic use because many cement kilns are configured to burn liquid fuels rather than solid fuels.

Further technical studies and regulatory decisions are required before the burning of both untreated and treated (painted) non-hazardous wood debris is a commercially viable debris management option. The viability of burning wood debris is subject to future regulatory changes.

7.3 RECYCLING

Recycling offers the most promising future for non-hazardous C/D debris management. A variety of recycling options for non-hazardous C/D debris are currently in use with varying degrees of success. While recycling options offer clear economic advantages for whole-structure

Table 7-2

SUMMARY OF WOOD ENERGY POLICIES IN STUDIED STATES

State Energy Policies	CA	CT	NC	NY	VT	VA	WA	WI
Current % of total elec. generation from all types of woods	1.9	<1	<1	<1	2.3	1.4	<1	0.6
% of total state industrial energy consumption	<1	NA	NA	14	<1	12	32	7.2
State policy specifically supports "clean" waste wood combustion	✓	✓	✓	✓	✓	✓	✓	✓
State policy explicitly recognizes wood from the waste stream as a viable fuel source	✓	✓		✓		✓		✓
State policy wants the combustion of wood for fuel to increase	✓	✓	✓	✓	✓	✓	✓	✓
State-level financial incentives exist for using wood as fuel		✓	✓	✓				✓

Source: NYSERDA, 1991

demolition projects, they are highly dependent on the stability of the market for the end-use product. Several recycle options follow:

- Shredded Wood
  - Landscape mulch (only untreated clean wood can be used in many states)
  - Bulking agent for MSW and sludge composting
  - Top soil additive
  - Daily landfill cover
  - Fiber mats used to improve seeding and vegetation growth

- Manufactured building products (e.g., particle board, press board)
- Malleable wood products (*Boston Globe*, 1993)
- Wood fiber for grass seed stabilizer (*Boston Globe*, 1993
- Other thermo-mechanically refined fiber products for use in molded, pressed, or woven items (Barthelmes, 1992)

- Scrap Metal
  - Recovery and reuse

- Concrete, Brick, Cinder Block, Stone, Glass, Plaster, Sheetrock, Tile, Asphalt Roofing Materials
  - Crushed for fill
  - Crushed for road base

A key technical factor inherent in any of these recycling options is the effectiveness of the debris separation techniques in providing a feedstock with high purity. Separation can be performed at the demolition site or at an offsite processing facility. Equipment requirements can vary from simple chippers and hoggers to a process train. A detailed analysis of debris processing equipment is beyond the scope of this study. Examples of the processing systems available for use include the following:

- conveyors
- sorting stations
- classification screens
- chippers and hoggers
- crushers and shredders
- magnetic separators
- flotation tanks
- air classifiers
- hammer mills
- vibrating screens (Brickner, 1992)

Without well-developed markets, C/D debris recycling will not be successful. Additional market research should be sponsored to evaluate potential products and markets, such as research on wood fibers for use in agrimats, furniture and other applications, which is sponsored by the U.S. Department of Agriculture.

In addition to economic issues, developing regulatory requirements may also act as impediments to recycling success. As new products are considered for development, it is recommended that regulatory evaluations be performed in advance at federal and state levels to identify potential impediments. This identification could result in early petitions for waivers or other regulatory relief if the process and end product appear to be environmentally sound. Likewise, early decisions could be made to abandon the research in unresolvable situations.

7.4 HANDLING

No specific storage, manifesting, packaging, or transportation requirements in addition to state or local requirements are recommended for non-hazardous C/D debris. Note that some states (e.g., Virginia) require that open truck loads of any material be covered.

7.5 RECOMMENDED MANAGEMENT PROTOCOL FOR NON-HAZARDOUS C/D DEBRIS

The recommended protocol for management of non-hazardous C/D debris is as follows:

1 Identify non-hazardous debris through screening and quantification as described in Section 5.0

2 Segregate the debris into the following categories through manual or mechanical processing:
   - wood
   - metal
   - concrete, brick, cinder block, stone, glass, plaster, sheetrock, tile, asphalt roofing materials
   - other

3 Select recycle markets for each type of debris category based upon cost-effective, available, and reliable processing facilities.

4 Incinerate the wood debris in a waste-to-energy facility or use the wood as fuel in a controlled burner. (Note: The viability of this option is subject to future regulatory changes.)

5 Select disposal of debris in a Subtitle D landfill only if all other options are not viable.

8.0 MANAGEMENT OF HAZARDOUS C/D DEBRIS

Hazardous construction and demolition (C/D) debris is that debris which exceeds the Toxicity Characteristic Leaching Procedure (TCLP) standard for lead or other hazardous compounds (characteristic hazardous waste), or contains a listed hazardous waste. Management of hazardous wastes is strictly regulated by the U.S. Environmental Protection Agency (EPA) under the Resource Conservation and Recovery Act (RCRA). Section 3.2 provides an overview of federal regulatory requirements for hazardous C/D debris.

This section provides additional information on hazardous waste generator status which affects hazardous waste management requirements. Information on treatment alternatives and disposal requirements for hazardous debris follows. The best demonstrated available technology (BDAT) standards for management of debris promulgated under the RCRA Land Disposal Restrictions (LDRs) are discussed, and other options such as burning in cement kilns are mentioned. Hazardous waste handling issues are also discussed and a recommended protocol for management of hazardous C/D debris is provided.

8.1 GENERATOR STATUS

RCRA defines a hazardous waste generator as any person (including individuals, companies, and government agencies), by site, whose act or process produces hazardous waste. In the case of hazardous lead-based paint (LBP) C/D debris, the generator may be the owner of the building or the demolition contractor. If the demolition contract does not require the contractor to manage the waste, then the owner is the generator. If the contractor is required to manage the waste, then the owner and the contractor are called cogenerators. An owner cannot contract away the responsibility and liability for safe management of the demolition waste. Federal categories are discussed below. States often have more stringent regulations than those presented.

The federal hazardous waste regulations distinguish three types of generators:

1 Those that generate no more than 100 kilograms (about 220 pounds) of hazardous waste per month are known as "conditionally exempt small quantity generators." These generators are required to dispose their wastes according to state regulations, which, in most states, means that they must label their waste and take it to a licensed solid waste disposal facility. However, some states require that even small quantities of hazardous waste be disposed at a licensed hazardous waste disposal facility. To qualify for disposal under the guidelines of this category, the generator must never accumulate more than 1,000 kilograms of waste on site. When this limit is exceeded, the generator immediately becomes subject to all the requirements pertaining to a small quantity generator.

2 Those that generate more than 100 but less than 1,CC0 kilograms of hazardous waste per month are known as "small quantity generators." These generators must comply with EPA hazardous waste regulations for accumulation, treatment, storage, and disposal of hazardous wastes. For this category, the generator may accumulate up to 6,000 kilograms on site for 180 days (or 270 days if the disposal site is more than 200 miles away).

3 Those that generate more than 1,000 kilograms of hazardous waste per month are known as "large quantity generators." These generators must comply with all EPA hazardous waste regulations, which include regulations for accumulation, treatment, storage, and disposal of hazardous wastes, as well as recordkeeping and reporting. The generators can store any amount for 90 days; when this time period is exceeded the generator is automatically considered a storage facility, which requires additional permitting.

Small and large quantity generators must obtain an EPA identification number for each demolition site. These numbers are used by EPA to track hazardous waste activities nationwide, including transportation, treatment, storage, and disposal of the waste.

8.2 TREATMENT

EPA's LDRs require hazardous debris to be treated prior to land disposal, using specific best demonstrated available technologies from one or more of the following families of debris treatment technologies:

- Extraction
- Destruction
- Immobilization

As an alternative to using specified technologies, hazardous debris may continue to be handled in accordance with the "contained-in" policy. Under this policy, the debris may be treated and land disposed if it no longer "contains" a hazardous waste. However, a case-by-case EPA regulatory determination is required with this alternative. This alternative is not an efficient regulatory strategy for generators with multiple large quantities of debris.

The result of performing treatment in compliance with BDAT would be two-fold. Not only would the debris no longer be prohibited from land disposal, but EPA would consider the treated debris to no longer be or contain a hazardous waste, provided a destruction or extraction technology is used for each debris type/contaminant co... ination and provided that the treated debris does not exhibit any hazardous characteristics. Such treated debris could, therefore, be reused, recycled, burned, or disposed in a Subtitle D facility. Table 8-1 shows the categories and technologies acceptable as BDAT for hazardous debris.

TABLE 8-1

ALTERNATIVE TREATMENT STANDARDS FOR HAZARDOUS DEBRIS

A. Extraction Technologies
  1. Physical Extraction
     a. Abrasive Blasting
     b. Scarification, Grinding, and Planing
     c. Spalling
     d. Vibratory Finishing
     e. High Pressure Steam and Water Sprays
  2. Chemical Extraction
     a. Water Washing and Spraying
     b. Liquid Phase Solvent Extraction
     c. Vapor Phase Solvent Extraction
  3. Thermal Extraction
     a. High Temperature Metals Recovery
     b. Thermal Desorption

B. Destruction Technologies
  1. Biological Destruction
  2. Chemical Destruction
     a. Chemical Oxidation
     b. Chemical Reduction
  3. Thermal Destruction

C. Immobilization Technologies
  1. Macroencapsulation
  2. Microencapsulation
  3. Sealing

Source: 40 C.F.R. Section 268.45 Table 1

The BDAT technologies for hazardous debris specified in Table 8-1 offer the generator and/or treater managing the waste a number of technology options, all of which are widely used treatment methods. Hazardous debris must be treated by one of the specified treatment technologies for each contaminant subject to treatment.

Residuals generated by the treatment of hazardous debris are subject to the numerical treatment standards for the waste contaminating the debris. Also, layers of debris removed by spalling are hazardous debris that remain subject to the treatment standards.

Specific performance and/or design and operating standards have been specified for various BDAT technologies. The physical extraction technologies which would be applicable to LBP debris have the following treatment standards, listed in Table 8-2.

TABLE 8-2

APPLICABLE TREATMENT STANDARDS
FOR PHYSICAL EXTRACTION

Debris Type	Standard
Glass, Metal, Plastic, Rubber	Treatment to a clean debris surface
Wood, Brick, Cloth, Concrete Paper, Pavement, Rock	Removal of at least 0.6 cm of the surface layer, treatment to a clean debris surface.

Source: 40 C.F.R. Section 268.45, Table 1

The LDRs for hazardous debris define a clean debris surface as "the surface, when viewed without magnification, shall be free of all visible contaminated soil and hazardous waste except that residual staining from soil and waste consisting of light shadows, slight streaks, or minor discolorations, and soil and waste in cracks, crevices and pits may be present provided that such staining and waste and soil in cracks, crevices and pits shall be limited to no more than 5% of each square inch of surface area." Other performance and/or design and operating standards for other technologies are also defined in Table 1, 40 C.F.R. Section 268.45.

The basic technical principle inherent in all physical extraction technologies is that the majority of the contaminants reside on the surface of the debris matrix, and are only shallowly absorbed into the matrix; therefore, the extraction of the surface layers through physical abrasion will remove the majority of the contaminants. This same principle is a side benefit of the size reduction techniques of chipping and hogging that precede both wood burning and most recycling options. Similarly, abatement techniques like sand blasting and experimental methods such as carbon dioxide pellet blasting, which is being researched by the EPA Risk Reduction Engineering Laboratory (Burkle, 1992), are based upon the same principle.

If the treatment process is effective and the treated debris does not exhibit any hazardous characteristics, then the debris would be classified as non-hazardous. It is possible that a non-hazardous classification could minimize concerns of waste wood markets (e.g., burning, recycling) regarding potential residual toxicity due to the presence of LBP, thereby opening those markets to treated wood debris. Note that the residuals from BDAT technologies must be managed as hazardous wastes.

The rigorous regulatory requirements for treatment of hazardous debris are associated with significant costs and management requirements such as manifesting, reporting and recordkeeping. Therefore, the volume of hazardous debris generated should be minimized. Proper segregation of materials and treatment using BDAT will contribute to meeting this goal.

8.3 BURNING

The burning of hazardous C/D debris contaminated with LBP in a RCRA-permitted facility could offer economic advantages over treatment and land disposal. The regulatory requirements governing each burning facility will determine allowable contaminant levels in incoming fuel, and will also correlate to tipping fees. In addition to RCRA-permitted incinerators, cement kilns and lead smelters are other potential markets. Burning for energy recovery is subject to the LDR requirements found at 40 C.F.R. Part 268.

8.3.1 CEMENT KILNS

Cement kilns are a potential option for burning C/D debris, both non-hazardous and hazardous. Cement kilns are currently operating under interim status compliance conditions regulated by the Boiler and Industrial Furnace Rule 40 C.F.R. Part 266, Subpart H. Each facility will be granted a permit by EPA on a case-by-case basis reflecting facility-specific operating specifications, including acceptance of wastes as fuel substitutes. A number of cement kilns are currently accepting some type of hazardous waste as an economic fuel substitute. The vast majority of these wastes are liquid hazardous wastes, therefore conversion may be required to accept solid fuel. One waste broker indicated that some cement kilns are using leaded debris for fuel and are not experiencing regulatory emission compliance problems unless the lead levels are "extremely high." (Fritsky, 1993) Materials that are burned for energy recovery are subject to the Part 268 LDR requirements.

The presence of metals in cement kiln fuel or raw material feed is not typically an environmental problem because many metals will volatilize and condense within the kiln and be bound into the clinker (cement kiln product). Volatile metals such as lead are more likely to volatilize in the kiln and condense outside of the kiln in the ductwork of the air pollution control device (APCD). Lead that remains in a particulate form, is collected in the highly-efficient APCD. Cement kiln dust (CKD) typically is highly alkaline and metals bound into the CKD are very insoluble. If the CKD generated when burning waste-derived fuel does not exhibit toxic concentrations compared to health-based limits (TCLP levels for metals) or if the CKD is demonstrated not to be significantly different from residue generated when burning conventional fuel, the CKD meets the Bevill exclusion (40 C.F.R. Section 266.112) and is considered to be a non-hazardous waste. If the CKD does not meet the Bevill exclusion, due to toxic metal concentrations or other hazardous characteristics, it may be recycled at a metal recovery facility or treated and disposed as a hazardous waste.

8.3.2 OTHER BURNING FACILITIES

Hazardous wood debris contaminated with LBP may be a potential supplemental fuel source for other manufacturing facilities, particularly those that process heavy metals and are equipped with APCDs to capture metal particulates. Demolition contractors are investigating regulatory and economic issues associated with sending lead-painted C/D wood debris to lead smelting facilities. No information was available regarding arrangements currently in place.

8.4 RECYCLING

Hazardous wastes that are recycled are subject to federal hazardous waste regulatory requirements, and state recycling regulations, where they apply. Generators are regulated by federal regulations in 40 C.F.R. Part 262; transporters are regulated in 40 C.F.R. Part 263; and hazardous waste recycling facilities are regulated in 40 C.F.R. Part 264.

Refer to Section 7.3 for a discussion of various potential recycling options for C/D debris. Metals recovery facilities are one possible market for hazardous lead-contaminated debris, particularly for the small particles or fines resulting from physical extraction processes. The ability of recycling facilities to accept hazardous debris is currently decided on a case-by-case basis with the exception of scrap metal recycling which is not subject to hazardous waste regulations: Further investigation is required to determine the extent or potential of recycling hazardous LBP debris.

8.5 HANDLING

The accumulation of hazardous waste at a generator's facility is regulated under RCRA, by 40 C.F.R. Section 262.34. The hazardous waste may be accumulated on site for 90 days or less without a permit, provided:

1 The waste is placed:
   - in containers, complying with 40 C.F.R. Part 265 Subpart I
   - in tanks, complying with 40 C.F.R. Part 265 Subpart J
   - on drip pads, complying with 40 C.F.R. Part 265 Subpart W
   - in containment buildings, complying with 40 C.F.R. Part 265 Subpart DD

2 Each container is marked with the date upon which accumulation began

3 Each tank or container is labeled or clearly marked with the words "Hazardous Waste"

4 The following volumes are not exceeded:
- 100 kg for a conditionally exempt small quantity generator
- 1,000 kg for a small quantity generator
- 6,000 kg for other generators

Generators of hazardous waste are required to comply with the following federal regulatory requirements:

- Generator Standards, 40 C.F.R. Part 262
  - hazardous waste determinations
  - EPA identification numbers
  - manifest requirements
  - pre-transport requirements (packaging, marking, labeling, placarding and accumulation time)
  - record-keeping and reporting requirements
  - hazardous waste export and import requirements
- Land Disposal Restrictions, 40 C.F.R. Part 268

Transportation of hazardous waste is regulated by Department of Transportation regulations 49 C.F.R. Parts 171 through 179. EPA has adopted these regulations which apply to both interstate, and intrastate transportation of hazardous waste in 40 C.F.R. Part 263.

8.6 RECOMMENDED PROTOCOL FOR HAZARDOUS C/D DEBRIS

The recommended protocol for management of hazardous C/D debris contaminated with LBP is as follows:

1 Minimize the volume of hazardous debris through segregation and testing.

2 If the volume of hazardous debris is small, select extraction or destruction treatment technologies appropriate to the matrix that is contaminated. Treat the debris in compliance with required performance or design and operating standards for that technology.

3 Test the treated debris using the TCLP to determine whether it exhibits the hazardous characteristic of lead toxicity.

4 If the treated debris is not characteristically toxic, treat it as a non-hazardous waste. Refer to Section 7.0 for recommended protocols for management of non-hazardous debris.

5 If the treated debris still exhibits the toxicity characteristic, retreat and retest it, or dispose of it in a Subtitle C disposal facility.

6 Manage the residuals generated by the treatment of hazardous debris as hazardous wastes. If appropriate and technologically feasible, recycling at a metals recovery facility may be an option.

7 If technologically feasible and in compliance with RCRA Subtitle C regulations, consider burning or reuse management options such as cement kilns or metals recovery facilities for large volumes of hazardous C/D debris.

8 Comply with all applicable storage, manifesting, packaging, labeling, marking, placarding, transportation, recordkeeping, and reporting requirements.

9.0 LEAD EXPOSURE

Concern over proper management and disposal of lead-based paint (LBP) is due to the fact that it causes detrimental effects to human health and the environment. This section discusses human health and environmental effects from lead exposure. The fate and transportation of lead in the environment is described, according to the lead species present and the characteristics of the media within which the lead exists. Also described is information regarding lead's leachability from landfills and combustion ash, and emissions of lead from waste burning facilities.

9.1 HUMAN HEALTH EFFECTS

Exposure to lead may result in numerous human health effects and toxicological symptoms. Variations in exposure levels produce a wide variety of human health effects. Current research suggests that toxic effects may result from lead exposure levels considerably lower than previously recognized. (56 *FR* 22096) Lead exposure levels are typically evaluated from the lead content of blood.

During the past decade, reduction in the environmental sources of lead (virtual elimination of leaded gasoline and voluntary removal of lead solder from food cans) has been attributed to the decrease in childrens' average blood-lead levels from approximately 17 micrograms per deciliter (µg/dl) to between 4 and 6 µg/dl. The Centers for Disease Control set the standard for blood-lead level poisoning at 10 µg/dl.

Children and unborn fetuses are especially vulnerable to toxicological effects from lead exposure. Symptoms such as anemia, mental retardation, and encephalopathy (brain tumors) are associated with high lead blood levels (>40-60 µg/dl) and death may occur with extremely high lead concentrations (>100 µg/dl). Toxicological effects from lower levels of lead may include slight increases in the blood pressure of adults and subtle deficits in attention span, hearing, learning ability, heme synthesis and vitamin D metabolism in children. Exposure to lead is also associated with reproductive effects in men and women, and with decreased birth weight and decreased physical and mental development in newborn children. (56 *FR* 22096)

The biological basis of lead toxicity is its ability to bind to ligating groups in bi-molecular substances crucial to various physiological functions, thereby interfering with these functions by, for example, competing with native essential metals for the sites, inhibiting enzyme activity, and inhibiting or otherwise altering essential ion transport. (Seinfeld, 1986)

Although most research has focused on lead exposure in children, health risk studies for adults show that ingested lead is stored primarily in bone tissue. Mobilization of lead from bone tissue may occur during periods of stress or greater metabolic requirements for calcium, such as during pregnancy or in individuals suffering from osteoporosis.

9.2 ENVIRONMENTAL EFFECTS

Toxicological effects from lead are frequently reported for both small and large animals. Sources of lead for animal uptake include ingestion of lead wastes, LBP, spent lead shot, fishing sinkers, and contaminated forage near lead smelters. Lead poisoning is the most frequently diagnosed toxicological problem in veterinary medicine. Lead poisoning has been reported for all domestic species and several species of zoo animals.

High concentrations of lead can affect certain plants causing inhibited rates of photosynthesis, reduced growth, and variation in species composition. Soil microbial ecology can be affected by high soil lead levels. Some detrimental effects include reduced rates of mineralization of soil organic matter, lowered nutrient levels, and changes in soil properties such as lower organic matter content. (56 *FR* 22096)

Microbial processes have been affected by the interaction of soil type and lead concentration (Dragun, 1988). Table 9-1 presents results from several studies that examined the interaction of soil type and metal concentration on microbial processes. For soils with increasing sorptive capacity (sandy loam > loamy sands), respiration was not inhibited by treatments consisting of increased levels of lead. Also, soils with increased levels of organic material (humic acids and compost) did not show reduced microbial respiration with high lead concentrations.

9.3 ENVIRONMENTAL FATE AND TRANSPORT

The following physical and chemical properties of lead were obtained from the Toxicological Profile for Lead (ATSDR, 1988) and the priority pollutant-related information for this metal (EPA, 1979), unless referenced otherwise.

Lead can occur in three oxidation states (0, +2 and +4) with the plumbous (+2) valence dominant in environmental chemistry. (Alloway, 1990) Lead is persistent in the environment and, therefore, has a long residence time relative to most other pollutants. Lead accumulates in soils and sediments because of its low solubility and resistance to microbial degradation. Lead is poisonous, and its bioaccumulation within the food chain and severe toxicity associated with human ingestion are important. No significant evidence has shown that lead has an essential role in metabolism.

TABLE 9-1

EFFECTS OF LEAD LEVELS IN SOIL ON MICROBIAL ACTIVITY

SOIL TYPE	LEAD CONC (ug/kg)	ORGANIC AMENDMENT	MICROBIAL PROCESS	ECOLOGICAL EFFECT	SOURCE
Loamy sand, pH 5	10	Not Applicable	Respiration	6% Decrease	1
Loamy sand, pH 5	100	--	Respiration	25% Decrease	1
Sandy loam, pH 5	1000	-	Respiration	None	3
Silt loam, pH 6.8	1000	--	Denitrification	Retardation	2
Sandy loam, pH 5	10,000	--	Respiration	Retardation	3
Sandy loam, pH 5	15,000	2% Humic acid	Respiration	None	3
Sandy loam, pH 5	20,000	4% Compost	Respiration	Initial Retardation; none after 20 days	3

Sources cited -
1. Cornfield, 1977;
2. Bollag and Barabasz, 1979;
3. Debosz et al., 1985.

Metallic lead is stable in dry air; however, in moist air, it quickly forms lead monoxide which transforms into lead carbonate through a reaction with carbon dioxide in the atmosphere. In general, the chemical properties of the inorganic lead compounds are similar to those of other alkaline earth metals. The lead nitrate, chlorate, and acetate salts are water soluble; the chloride is slightly soluble; and the sulfate, carbonate, chromate, phosphate, and sulfides are relatively insoluble. The chromate, carbonate, nitrate, sulfide, and phosphate salts are soluble in acid, and the chloride is slightly soluble in acid. (Weast, 1985)

Lead typically forms complexes of low solubility with the major anions of natural environmental systems. Table 9-2 lists the solubility product constants (K_{sp}) for eleven lead minerals. The listed values are negative logarithms of the K_{sp} and the very large values indicate low solubility for the various minerals. The hydroxide, carbonate, sulfide, and sulfate (less commonly available) compounds may act as solubility controls.

TABLE 9-2

SOLUBILITY PRODUCT CONSTANTS FOR LEAD MINERALS

MINERAL	pK_{sp} [a,b]
$PbCl_2$	4.80
$PbCO_3$	13.48 (18°C)
PbO	15.32
PbO_2	65.50
$Pb(OH)_2$	19.90
$Pb_4O(PO_4)_2$	65.17
$Pb_3(PO_4)_2$	44.60
$Pb_5(PO_4)_3Cl$	84.40
$Pb_5(PO_4)_3OH$	76.80
PbS	27.47 (18°C)
$PbSO_4$	7.97 (18°C)

Notes:
a = negative logarithm of the solubility product constant K_{sp}
b = at 25°C, unless specified otherwise.
Source: Dragun, 1988

The transport of lead is influenced by the speciation of the ion. One method for estimating the speciation of the lead ion is the examination of hydrogen ion concentration and oxidation/reduction potential (ORP) for a particular system. The hydrogen ion concentration is recorded by pH electrode measurements and the ORP is determined by a platinum electrode and reported as Eh. The units of Eh are volts or, more commonly, millivolts. Following measurements of Eh and pH, an estimate of the ionic species can be made using Eh-pH diagrams.

In conjunction with ionic species information from Eh-pH diagrams, mobility of lead in soils and groundwater is determined by the potential for adsorption. Estimates of adsorption are based on the adsorption coefficient or distribution coefficient (K_d). The K_d for lead is an experimentally determined value (mL/g) which is defined as the ratio of the concentration of lead adsorbed onto soil surfaces (µg Pb per g soil) divided by the concentration of lead in water (µg Pb per mL water). For lead, the observed range of K_d is 4.5 to 7,640 mL/g. Following a logarithmic transformation of the data, a mean of 4.6 and standard deviation of 1.7 were reported for the logarithms of the observe 'ues. (Dragun, 1988) Assessment of potential groundwater contamination is conside : values of K_d that are < 5 mL/g and typically for K_d <1 mL/g. The observed range for k K_d values further supports the high degree of soil adsorption for lead.

Lead is found in soils, rocks, sediments, surface water and groundwater. Average [illegible] concentrations of 16 µg/kg lead are reported for soil levels ranging from 15 to 25 mg/kg (Burau, 1982). A typical range for soil lead values is from 2.0 to 200 mg/kg with extreme limits [illegible] [illegible]000 mg/kg (Dragun, 1988). Atmospheric deposition of lead onto the soil surface is a primary source of anthropogenic lead; however, research indicates that nearly constant values for lead are found below the 5 cm depth. (Ward et al., 1975) Lead is considered a trace element in groundwater with natural concentrations of <15 µg/L. (Dragun, 1988) Lead exists primarily as the divalent cation in most unpolluted surface waters and becomes sorbed onto particulate phases. In polluted surface waters, the chemical form of lead may be markedly altered by organic material.

Wong et al. (1975) reported the production of tetramethyl lead ($(CH_3)_4Pb$) by microorganisms in lake sediments from inorganic and organic lead compounds. Air analysis of flasks containing anaerobic lake sediments indicated tetramethyl lead was produced and could be volatilized. The kinetics of degradation of tetramethyl lead in aerobic waters are uncertain and this compound is probably not stable in oxidizing environments. Biomethylation of lead represents a mechanism for the reintroduction of lead from bed sediments into the aqueous environment or atmosphere.

Sorption of lead appears to dominate the fate of lead in the environment. In aquatic and estuarine environments, lead is accumulated within bed sediments apparently due to sorption phenomena. (Helz et al., 1975 and Valeila et al., 1974) Variation in sorption mechanisms has been attributed to parameters such as geological setting, pH, Eh, ligand availability, dissolved and particulate iron concentrations, salinity, sediment composition, and initial lead concentration. Complexation of lead by biogenic ligands can be significant in polluted waters and therefore may have a significant effect on the fate of lead in aquatic environments. No evidence has been reported describing the photolysis of organo-lead compounds in natural waters.

Bioaccumulation of lead has been shown for a variety of organisms. Microcosm studies suggest that lead is not biomagnified. Lu et al. (1975) studied the fate of lead in three ecosystems differing only in their soil substrate. The ecosystems contained algae, snails, mosquito larvae, mosquito fish, and microorganisms. Lead was concentrated most by the mosquito larvae and least by the fish. Body burdens and aqueous lead concentrations appeared to be strongly correlated with the soil chemical properties of organic matter content and cation exchange capacity.

The photolysis of lead particles from automobile exhausts indicates the conversion from halide salts ($PbBr_2$, PbBrCl, etc.) to oxides, carbonates, and sulfates. (Kabata-Pendias and Pendias, 1984)

In summary, the dominant mechanism controlling the fate of lead appears to be sorption. Precipitation of $PbSO_4$, $PbCO_3$, and PbS, and bioaccumulation may also be important. The mobility of lead is inversely affected by pH levels with increasing mobility reported as pH decreases. In alkaline and near-neutral environments, immobilization of lead by sorption and precipitation may occur relatively quickly.

9.3.1 LEACHABILITY FROM LANDFILLS

Data on the leachability of lead from landfills indicates that while lead may leach from landfills, it becomes heavily diluted in groundwater. In addition, lead is very immobile in soils. Data on lead's lack of mobility in the environment as presented in Section 9.3. This section presents data on the small amounts of lead that may become mobile from both municipal solid waste (MSW) landfills and from construction/demolition (C/D) debris landfills. Although the construction requirements and geologies were not accounted for, one study found that the leachate from the MSW landfills is ten times more concentrated than leachate from C/D landfills. (Lambert, 1992)

Data on lead leaching from C/D landfills is available from a study conducted in 1982 by the Connecticut Department of Environmental Protection. This study collected leachate data from five bulky waste landfills. Connecticut defines bulky waste as land clearing debris and waste resulting directly from demolition activities other than clean fill. Lead in leachate was found in the range between 0.04 mg/L and 0.1 mg/L, with an average of 0.056 mg/L. The Safe Drinking Water Act's Maximum Contaminant Level (MCL), a level for which compliance is normally required, is 0.05 mg/L for lead. The report concludes that: (1) the average from these five landfills should be representative of typical demolition landfill sites where leachate is produced and collected; and (2) demolition landfills are not totally innocuous and can have adverse effects on adjacent surface water or groundwater (Lambert, 1992). It is relevant to note that the lead values represent steady-state leachate strength from unsaturated lysimeters, prior to dispersion and dilution in the aquifer.

MSW landfills are different from C/D landfills in that MSW decomposes much more than C/D waste. The composition of leachate from MSW will be highly dependent upon the stage of decomposition and the materials that are contained within the MSW landfill. It is therefore difficult to generalize as to the particular contaminant concentrations that leachate will contain.

Reported MSW leachate concentrations for lead vary from non-detected to 6.6 mg/L. A study done in Wisconsin with 46 samples found that MSW leachate concentrations for lead vary between non-detected to 1.2 mg/L. (Robinson, 1986) By comparison, the MSW maximum value is two orders of magnitude higher than the MCL for lead.

Lead has leached from both C/D landfills and MSW landfills in concentrations higher than the MCL for lead. Groundwater with constituent concentrations beyond the MCL normally requires corrective action.

9.3.2 LEACHABILITY FROM COMBUSTION ASH

Wood ash contains the oxidized minerals from the wood, as well as noncombustible material such as dirt and any unburned carbon. The single major constituent of both demolition wood ash and natural wood ash is silicon dioxide, or dirt, averaging 41 percent for demolition wood and 35 percent for natural wood. The second most concentrated mineral in both types of ash is calcium oxide, averaging about 16 percent by weight for demolition wood and 23 percent for natural wood. Calcium oxide, along with other oxides (e.g., aluminum, iron, magnesium, potassium and sodium) is primarily responsible for the widely recognized alkalinity of wood ash. These minerals are typically present in large percentages, and as a result, wood ash is often used as a liming agent for land application. Demolition wood ash and whole tree chip ash exhibit very similar compositions. The main differences between the two are due to the increased amount of dirt often found in demolition wood, as well as higher amounts of sulfur- and titanium-containing non-wood materials. (Grasso, 1990)

When heavy metals were analyzed from wood ash, the metal present in the highest concentrations in demolition wood ash was titanium. Lead was present in the second highest average concentration. The main sources of both of these metals is paint. Other sources include different coatings and impregnates. If the demolition wood is burned together with another fuel (e.g., whole tree chips or biomass), then the metal concentrations in the ash will be reduced. Metal concentrations in combustion ash from a study on the composition of recycled wood fuel are shown in Table 9-3. (Grasso, 1990)

TABLE 9-3
LEAD CONCENTRATIONS IN COMBUSTION ASH
(mg/kg)

	Minimum	Maximum	Average
Virgin wood	16.6	36	23
Demolition wood	22.0	33,000.0	6,261.0

Source: (Grasso, 1990)

Ash from wood waste combustion is a solid waste and is subject to a hazardous waste determination. New York State requires waste characterization of the ash generated from burning solid waste, refuse-derived fuel, and household waste, regardless of whether energy recovery is provided. (New York Solid Waste Management Facility Rules Section 360-3 5) In addition to specific disposal requirements for hazardous waste ash, the state has specified disposal criteria for non-hazardous bottom ash and fly ash. The ash from burning clean waste wood is regulated as a solid waste. (NYSERDA, 1991)

In a study on demolition wood, EP Toxicity and TCLP tests were performed for metals on four composite ash samples resulting from the laboratory combustion of 100 percent demoliton wood. Lead was present at less than the federal level using the EP Toxicity test, and in exceedence of the maximum acceptable limits for TCLP. (Jana et al., 1991) A different study of leachability of metals from MSW ash found that lower levels of metals were leached when the ash was monofilled, as compared to codisposing the ash with untreated MSW. (Francis and White, 1987) A possible explanation for this may be that ash from incinerators with scrubbers may exhibit higher buffering capacity because of the lime used in the scrubbers. This buffering capacity would not be depleted in monofills, but would be depleted in the presence of acids normally found in MSW landfills.

9.3.3 AIR EMISSIONS

Air emissions of lead are more of a problem at a demolition site than at [illegible]ing facility, due to effective air pollution control equipment. Studies have shown that with an efficient particulate control system, a recycled wood-fired facility can easily reduce metal emissions from painted wood combustion to a level below regulatory limits. Even if a facility burned 100 percent treated wood, metal emissions could be maintained below regulatory limits with conventional particulate collection devices. (Grasso, 1990)

Atmospheric lead is a localized problem, and therefore all activities regarding demolition of LBP materials should seek to minimize the dust created. [illegible]ently, the Clean Air Act's primary and secondary standards require that not more than an [illegible]e of 1.5 $\mu g/m^3$ of lead may exist in the atmosphere averaged over a 90-day period. Furthe[illegible], lead emissions may also be a component of respirable particulate matter in the atmosphere. Currently, not more than 450 $\mu g/m^3$ of particulate matter less than 10 μm (dust small enough to be inhaled into the deepest portion of the lungs) can be in the atmosphere, averaged over an eight-hour workday.

10.0 RECOMMENDED PROTOCOLS

The major findings and recommended protocols for sample collection, sample analysis, non-hazardous construction/demolition (C/D) debris management, and hazardous C/D debris management are presented in the following sections.

10.1 SAMPLE COLLECTION

Section 5.0 presents a detailed discussion of recommended sample collection protocols for permeable debris. Non-permeable building components such as glass, screen, aluminum siding, metal ductwork, bulky process and utility equipment, steel tanks, and I-beams should be segregated and managed separately due to their high salvage values. The recommended sample collection protocols for permeable debris consist of the following components:

1 Plan the sampling in detail, including:

- Research the structure
- Inspect the structure
- Perform lead screening on all structure components
- Develop Sampling and Analysis Plan/Quality Assurance Project Plan
- Perform Job Hazard Analysis and Develop Health and Safety Plan

2 Remove non-permeable components from the structure for recycle, reuse or other salvage purposes.

3 Select a sampling approach for permeable components based upon screening results. Determine subsamples to be composited and timing of sampling (before or after demolition). Figure 10-1 summarizes the four recommended approaches. Recommendations include:

- Before Demolition
  Case 1 - analysis of composite of all permeable high-risk components that indicates the presence of lead <u>and</u> analysis of a composite of all permeable low-risk components that indicates the absence or low levels of lead. Case 1 is recommended when the high-risk components are suspected to be hazardous.
  Case 2 - analysis of a composite of all permeable low-risk components that indicates the absence or low levels of lead <u>and</u> analysis of a composite of all permeable components. Case 2 is recommended when the presence of lead has been detected in some components, but the entire structure is suspected to be non-hazardous.
  Case 3 - analysis of a composite of all permeable components. Case 3 is recommended if all screening results indicated the absence or low levels of lead.

  After Demolition - analysis of one or more composites of the permeable debris pile, collected randomly.

FIGURE 10-1
SUMMARY OF RECOMMENDED SAMPLING APPROACHES FOR PERMEABLE DEMOLITION DEBRIS

Before Demolition - Case 1

Composite + **Composite –**

Rationale - Recommended when the high-risk (+) components are expected to be characteristically hazardous.

Benefit - Expect to prove that Composite – is non-hazardous and keep Composite + segregated to reduce hazardous volume.

Risk - None.

Before Demolition - Case 2

Composite – **Composite All**

Rationale - Recommended when the entire structure is not expected to be characteristically hazardous even though some components had high-risk screening results.

Benefit - Expect to prove that Composite – is non-hazardous and hope to prove that Composite-All is non-hazardous.

Risk - If Composite-. is hazardous, reanalysis (per Case 1) is required to determine hazardous fraction.

Before Demolition - Case 3

Composite All

Rationale - Recommended when screening indicated the absence of or low levels of lead on all components.

Benefit - Single TCLP analysis.

Risk - If entire building tests hazardous then resampling/analysis must occur.

Before Demolition - Case 4

Composite Pile

Rationale - Recommended wh e entire structure is not expected to be char teristically hazardous and few/no components had high-risk screening results. Also recommended when it is more feasible and/or cost-effective to process or segregate components following demolition.

Benefit - Single TCLP analysis. Simplified sampling if performed on grid basis.

Risk - If entire building tests hazardous and resampling does not change result, may be forced to segregate and resample or dispose entire structure as hazardous.

Key:

+	Composite of permeable components that indicate high presence of lead (high-risk components) based on screening prior to demolition
–	Composite of permeable components that indicate low/no presence of lead (low-risk components) based on screening prior to demolition
All	Composite of permeable components represented within the entire . prior to demolition
Pile	Composite from pile of permeable components from demolishe ture.

4 Perform sampling including QA/QC samples. Use 1/4-inch to 1-inch drill bits. Drill through the entire substrate or pile, and collect the drill cuttings and associated dust.

5 Evaluate sampling results to make a hazardous determination for each set of building components represented by a composite sample.

6 If sample results are unexpected (e.g., composite of permeable low-risk components exceeded 5.0 mg/L in TCLP), use the rationale in Table 5-4 to determine whether additional sampling and analysis is warranted.

10.2 SAMPLE ANALYSIS

Waste generators are required to determine whether or not their waste is hazardous. A waste may be hazardous because it is a listed waste or because it exhibits a hazardous characteristic. Lead-based paint (LBP) is not a listed waste and of the four hazardous waste characteristics, the one applicable to LBP is toxicity. Toxicity testing requires analysis of the waste using the Toxicity Characteristic Leaching Procedure (TCLP).

Screening methods such as X-ray fluoresence (XRF) or chemical test kits should not be used to quantify lead levels, because the results are subject to equipment limitations and do not correlate to TCLP levels. However, these screening tools are options for determining the absence or presence of lead to support the sampling process during demolition planning.

Note that federal agencies do <u>not</u> currently recommend using chemical test kit results as the basis for making decisions about abatement of lead in paint, soil, and dust. This recommendation should also be considered for demolition wastes. Several chemical test kit evaluations are underway. After the evaluations are completed, updated information will be available through the National Lead Information Center. (National Lead Information Center, 1993) Also refer to the U.S. EPA Office of Pollution Prevention and Toxics study described in Section 11.3.2.

Additional information on sample analysis is discussed in Section 6.0.

10.3 NON-HAZARDOUS C/D DEBRIS MANAGEMENT

Section 7.0 presents a detailed discussion of management options for non-hazardous C/D debris including landfilling, burning and recycling. The recommended protocol for management of non-hazardous C/D debris is as follows:

1 Identify non-hazardous debris through screening and quantification as described in Section 5.0.

2 Segregate the debris into the following categories through manual or mechanical processing:

- wood
- metal
- concrete, brick, cinder block, stone, glass, plaster, sheetrock, tile, asphalt roofing materials
- other

3 Select recycle markets for each type of debris category based upon cost-effective, available, and reliable processing facilities.

4 Incinerate the wood debris in a waste-to-energy facility or use the wood as fuel in a controlled burner. (Note: The viability of this option is subject to future regulatory changes.)

5 Select disposal of debris in a Subtitle D landfill only if all other options are not viable.

10.4 HAZARDOUS C/D DEBRIS MANAGEMENT

Section 8.0 presents information on management requirements for hazardous C/D debris, including generator status, treatment, burning, recycling, and handling. The recommended protocol for management of hazardous C/D debris follows:

1 Minimize the volume of hazardous debris through segregation and testing.

2 If the volume of hazardous debris is small, select extraction or destruction treatment technologies appropriate to the matrix that is contaminated. Treat the debris in compliance with required performance or design and operating standards for that technology.

3 Test the treated debris using TCLP to determine whether it exhibits the hazardous characteristic of lead toxicity.

4 If the treated debris does not exhibit the toxicity characteristic, treat it as a non-hazardous waste. Refer to Section 7.0 for recommended protocols for management of non-hazardous debris.

5 If the treated debris still exhibits the toxicity characteristic, retreat and test it, or dispose it in a Subtitle C disposal facility.

6 Manage the residuals generated by the treatment of hazardous debris as a hazardous waste. If appropriate and technologically feasible, recycling at a metals recovery facility may be an option.

7 If technologically feasible and in compliance with RCRA Subtitle C regulations, consider burning or reuse management options such as cement kilns or metals recovery facilities for large volumes of hazardous C/D debris.

8 Comply with all applicable storage, manifesting, packaging, labeling, marking, placarding, transportation, recordkeeping, and reporting requirements.

11.0 CONTINUED PROGRESS

This report represents a "snap-shot" in time of the state of the issues regarding management of whole-structure demolition debris containing lead-based paint (LBP). Recommended protocols have been developed and presented for such important activities as sample collection, sample analysis, non-hazardous construction/demolition (C/D) debris management, and hazardous C/D debris management. The use of these protocols by contractors performing demolition for federal, state, municipal, and private clients will improve consistency and compliance with applicable regulations. Use of the protocols will also result in the generation of additional data to further refine the protocols and contribute to our collective knowledge base in this area.

Continuous improvement will also arise from a unified effort involving the interested and affected parties to share information, investigate and evaluate alternative methods, and develop strategies for improved approaches to this complex issue.

This section of the report presents a general three-step approach for making continued unified progress in addressing this waste management challenge (Section 11.1). Recommendations for continued progress in technical, economic, and regulatory areas are discussed in Section 11.2. Section 11.3 summarizes a number of ongoing studies that will yield other relevant information.

11.1 GENERAL APPROACH

The first step in the general three-step approach for continued improvement in the management of whole-structure demolition debris containing LBP is to identify and receive committed participation from interested and affected parties. Participants may include but are not limited to the following:

Federal Regulatory Agencies

- U.S. EPA Regions I through X, including laboratories
- U.S. EPA Office of Solid Waste
- U.S. EPA Office of Pollution Prevention and Toxics
- U.S. EPA Office of Research and Development
- U.S. Department of Housing and Urban Development (HUD)
- U.S. Occupational Safety and Health Administration
- U.S. Department of Agriculture (Forest Products Research Laboratory)

State Regulatory Agencies

- State Solid Waste Agencies

Department of Defense

- U.S. Army Environmental Hygiene Agency
- U.S. Navy
- U.S. Air Force, Armstrong Laboratory, Brooks Air Force Base

Department of Energy (DOE)

- Waste Management Representatives at DOE Headquarters and Facilities

Contractors

- Demolition Industry (e.g., National Association of Demolition Contractors)

Industry Groups

- Solid Waste Management Associations (representing waste-to-energy facilities and landfills)
- Lead Recycling Industry (e.g., Lead Industries Association)
- Cement Kiln Industry (e.g., Cement Kiln Recycling Association)

Other Involved Organizations

- American Society for Testing and Materials
- National Institute for Standards and Technology

The second step in the improvement process is for the interested and affected parties to recognize and accept the major goals of the developing LBP C/D management strategy including the following:

- Protect human health and the environment from risks posed by sampling, testing, handling, managing, recycling, burning, treating and disposing C/D debris containing LBP.

- Develop more cost-effective and reliable methods to manage C/D debris.

- Minimize the volume of waste determined to be hazardous.

- Increase the volume of waste being recycled and reused.

- Increase the volume of waste converted to energy through burning.

- Increase the volume of hazardous wastes being treated and decrease the volume of hazardous wastes being disposed.

The third step in this process is to continue to evaluate current practices through the assistance of the "experts" in this issue. These experts are persons who are currently involved in the management of whole-structure demolition debris containing LBP and who have the most relevant information to contribute to possible solutions. Current debris management practices such as sampling, testing, recycling, reuse, burning, treatment, and disposal should be evaluated in the following detailed areas.

- cost
- demonstrated performance
- availability
- environmental risk
- technical restrictions
- regulatory restrictions
- regulatory and institutional impediments
- available data

Effective and wide-reaching data collection strategies should emphasize the benefits of teamwork by all parties involved (regulators, generators, contractors, recyclers, treatment facilities, etc.) in addressing this issue. Contacts with the following types of organizations are recommended to maximize the communication networks existing within these organizations:

- Magazines specializing in recycling and demolition may print letters, articles, and informal information requests.
- National and regional organizations may solicit information from their members in periodic newsletters. The organizations may be willing to assist in the interpretation of the information. Examples of cognizant organizations include the following.
    - National Solid Waste Management Association
    - National Governors Association
    - Association of State and Territorial Solid Waste Management Officials
    - Solid Waste Association of North America
    - National Association of Demolition Contractors

11.2 RECOMMENDATIONS FOR CONTINUED PROGRESS

Additional infromation will continue to improve the current management approach, specifically in the technical, economic, and regulatory areas. Recommendations for continued progress in these three areas follow

11.2.1 TECHNICAL

Continued progress in the following technical areas is recommended.

- Gather and evaluate data comparing toxicity characteristic leaching procedure (TCLP) and synthetic precipitation leaching procedure (SPLP) for lead-contaminated materials. Determine appropriate protocol to predict potential leaching.
- Gather and evaluate data regarding dilution/attenuation factors for lead. Determine effect on definition of characteristically toxic wastes.
- Perform research on new products and uses for recycled materials such as wood fiber products and patented cold mix asphalt.
- Perform leachate studies to quantify risks (if any) associated with various management options, including but not limited to the following:
  - C/D landfill disposal
  - MSW landfill disposal
  - landscape mulching
  - wood fiber applications (agrimat)
  - burning (bottom ash, fly ash, emissions)
- Quantify human and environmental exposure risks during demolition.
- Develop protocols for demolition activities to protect human health and the environment.
- Improve lead screening tools to identify absence or presence of lead and to facilitate segregation of hazardous versus non-hazardous debris (e.g., X-ray fluorescence (XRF) and chemical test kits).
- Quantify effectiveness of chippers/hoggers in removing LBP from debris wood. Test wood chips and fines for toxicity.
- Investigate variability in analytical results due to sample collection and preparation methods, including drills, saws, punches, and other devices.
- Gather and compile available analytical data from demolition and abatement projects to assess correlations between leachable lead levels and total lead levels. Also consider relevant factors such as substrate type, paint thickness and lead content of the paint.

11.2.2 ECONOMIC

Continued progress in the following economic areas is recommended:

- Evaluate appropriateness of increasing landfill tipping fees for non-hazardous debris to discourage disposal

- Evaluate appropriateness of establishing surcharges on burning virgin materials, as opposed to recycled materials, to encourage acceptance of C/D debris for waste-to-energy conversion.

- Modify technical specifications, procurement policies, and price preferences for materials for construction projects (highways, buildings, etc.) to increase use of recycled materials.

- Perform market research for recycled products. Consider the following:

  - generation rates
  - end use markets
  - tax credits
  - sales and property tax exemptions
  - grant proposals for entrepreneurial business

11.2.3 REGULATORY

Continued progress in the following regulatory areas is recommended:

- Determine applicability of an exemption for recycled hazardous LBP debris under the Requirements for Recyclable Materials, similar to current exemption of scrap metals, 40 C.F.R. Section 261.6(a)(3)(iii).

- Determine applicability of an exclusion for hazardous LBP debris similar to the current exclusion for arsenical-treated wood or wood products, 40 C.F.R. Section 261.4(b)(9).

- Evaluate available data and determine appropriateness of modifying lead toxicity characteristic levels based on dilution attenuation factors.

- Quantify, evaluate and eliminate siting impediments for C/D debris reprocessing facilities.

- Institute waste bans in all states restricting landfilling or incineration of recyclable, reusable, or compostable wastes.

- Evaluate inconsistencies among state/local requirements to prevent the legal or illegal disposal of one state's wastes in another state due to less stringent requirements. The Northeast Waste Management Officials' Association (NEWMOA) report addresses this subject for NEWMOA states. Areas to be addressed include but are not limited to the following for landfills, reprocessing facilities and thermal destruction units:

  - definitions
  - management standards
  - disposal limitations
  - penalties
  - enforcement approaches

- Investigate regulatory restrictions on recycling of secondary lead waste (e.g., baghouse dust resulting from burning C/D debris).

11.3 ONGOING STUDIES

A number of studies are being conducted by various organizations related to the management of demolition debris containing LBP. A brief summary and a suggested contact are presented for each study.

11.3.1 U.S. ARMY ENVIRONMENTAL HYGIENE AGENCY

The U.S. Army Environmental Hygiene Agency (AEHA) performed a study to assess the waste characteristics of debris that is contaminated with LBP. The study focused on the debris generated from the demolition of Army WWII-era structures but also addresses other waste items such as those resulting from abatement and renovation activities. The report associated with this study is entitled "U.S. AEHA Interim Final Report, Lead-Based Paint Contaminated Debris - Waste Characterization Study No. 37-26-JK44-92, May 1992 - May 1993."

The conclusions of this study follow:

a. Characterization: Whole-Building Demolition Debris. The findings showed that (statistically) whole-building demolition debris (e.g., Army WWII-era structures) can be characterized as non-hazardous waste so long as certain assumptions/assertions are made:

   (1) Other hazardous components such as asbestos or PCBs (from light ballasts and roofing tars) are not present/or are removed and disposed separately.

   (2) Metals components such as ductwork, furnace/boilers, piping, or siding are removed to the extent feasible as scrap materials for reuse/recycling.

   (3) All remaining material (i.e., all those materials that were included in the sampling process such as both painted and unpainted wood components, brick, concrete, foundation material) must comprise a single wastestream at the point of generation (when the building is demolished). This wastestream must be handled as a single, discrete wastestream and disposed of all together.

b. Characterization: Small-Scale Debris. Debris that is generated during renovation, maintenance, or abatement activities such as paint chips, blast grit/media or personal protective equipment is more likely to be characterized as "hazardous" due to the concentrated mass of LBP. For these types of wastes, hazardous waste generation can be minimized through waste segregation techniques. For some wastes, cost savings can be achieved through minimizing sampling and analyses.

c. Disposal.

   (1) Non-hazardous Waste. While disposal in a C/D debris landfill may be appropriate and relatively inexpensive at this time, generators should consider other options that offer more than an "out-of-sight, out-of-mind"

solution. In fact, new/impending restrictions on C/D debris landfills may force the cost of this disposal option to greatly increase. Other options may be less expensive and/or more environmentally acceptable. State and/or local regulatory involvement will be necessary when assessing the feasibility of such alternatives.

(2) Hazardous Waste. The volume of LBP-related hazardous waste should be minimized to the extent most feasibly and economically possible. This can be done through careful assessment of operations and segregation of wastestreams as well as separation of contaminated items or removal of LBP.

(3) Recycling. Many items such as metal ductwork, piping, and siding can be salvaged from buildings that are to be demolished for recycling/reuse. Recycling can provide economic gains in addition to the environmental benefits associated with a reduced wastestream.

Recommendations presented in this study are:

a. Identify whole-building demolition debris wastestream populations that meet the descriptions discussed in this report.

b. Characterize such waste as non-hazardous, pending concurrence from state and local agencies.

c. Identify other sources of lead-paint-containing waste and debris. Determine appropriate waste segregation and management procedures based on cost-analyses and findings discussed above

d. Evaluate the potential for environmental media (e.g., soil) contamination at demolition sites, specifically with regards to future-use scenarios and human health-risk

e. Develop SOPs for demolition site operations to minimize environmental contamination and health hazards.

f. Assess current disposal procedures for demolition debris. Correct deficiencies/make amendments to contracts and/or SOPs with regard to final destination, liabilities, and control.

g. Evaluate disposal options and alternatives with regards to environmental and other regulatory requirements, cost, and other benefits/disadvantages.

Veronique Hauschild at the U.S. Army Environmental Hygiene Agency may be contacted for more information at (410) 671-2953.

11.3.2 U.S. EPA OFFICE OF POLLUTION PREVENTION AND TOXICS

The U.S. EPA Office of Pollution Prevention and Toxics (OPPT) is conducting a study comparing results from various technologies for field measurement of lead in LBP.

(Schwemberger, 1993) The results of the study will be considered by HUD in the development of guidelines for abatement of federally assisted housing.

The ongoing study evaluates the variability in common LBP field measurement techniques including six brands of lead test kits and nine types of portable XRF instruments. Painted surfaces in houses in Denver and Philadelphia are being tested using both types of field measurement devices. Confirmation samples are being analyzed at fixed-based laboratories using standard analytical instruments. The following painted surfaces are being analyzed in each house: metal, wood, concrete, brick, drywall, and plaster.

The field phase of the study is scheduled to e   id through October 1993 with a draft report scheduled to be completed by February 1994. For more information regarding this study, contact John Schwemberger, U.S. EPA Office of Pollution Prevention and Toxics, ‾02) 260-7195.

11.3.3 U.S. AIR FORCE ARMSTRONG LABORATORY

The Department of the Air Force Armstrong Laboratory at Brooks Air Force Base, Texas, is developing a LBP procedural guide for installation engineers tasked with abatement/disposal diagnosis of LBP in the Air Force. (Fisher, 1993) Further information is available from Lt. Catherine Fisher, Armstrong Laboratory, at (210) 536-3305.

11.3.4 CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION

The Connecticut Department of Environmental Protection (CT DEP) is preparing a brief question and answer (Q&A) guide on the subject of LBP structure sampling, characterization, and assessment. (Binnell, 1993) The Q&A guide will include a waste characterization approach that will rely primarily on portable XRF readings to support sampling, segregation, and disposal decisions during whole-structure demolition. The approach under development currently includes the following steps:

1. Characterize painted surfaces using a portable deep penetrating XRF device and select the average, or perhaps the highest, XRF value.

2. Estimate the painted surface area.

3. Determine the product of the painted surface area (2) and the XRF concentration (1) to yield the mass of lead in the structure (safety factors may be recommended to provide conservative estimates of total lead mass due to potential error in surface area determinations and XRF readings).

4. Estimate the mass of the structure to be disposed using average densities and estimated volumes of building components (e.g., wood, concrete, brick, plaster)

5. Determine the estimated lead concentration in the structure using the estimated lead mass (3) divided by the estimated building mass (4)

   Compare the estimated lead concentration in the structure (5) to a "recognized value" (e.g., 50 mg/kg total lead which represents a dilution factor of 10 compared to the TCLP method limit of 5 mg/L).

7. If the estimated lead concentration is higher than the "recognized value," then handle the building as a hazardous waste or perform more sampling, and possibly segregation, prior to demolition.

8. If the estimated lead concentration is lower than the "recognized value," then handle the building as a non-hazardous waste. (Binnell, 1993)

Information may be obtained by contacting the Waste Engineering and Enforcement Division of the CT DEP at (203) 566-4869.

11.3.5 EPA/HUD TITLE X

EPA and HUD are also working on other lead abatement issues according to mandates in the Title X legislation.

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